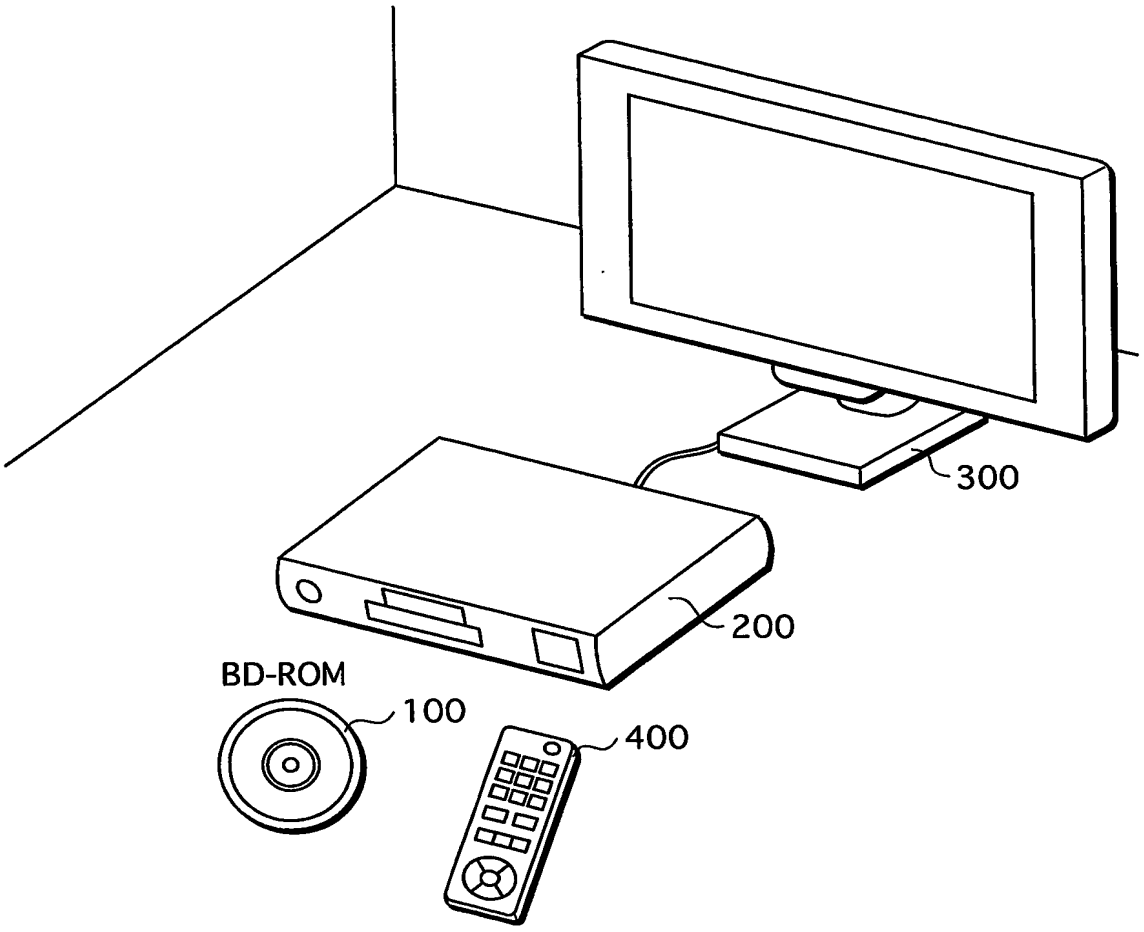
FIG.1



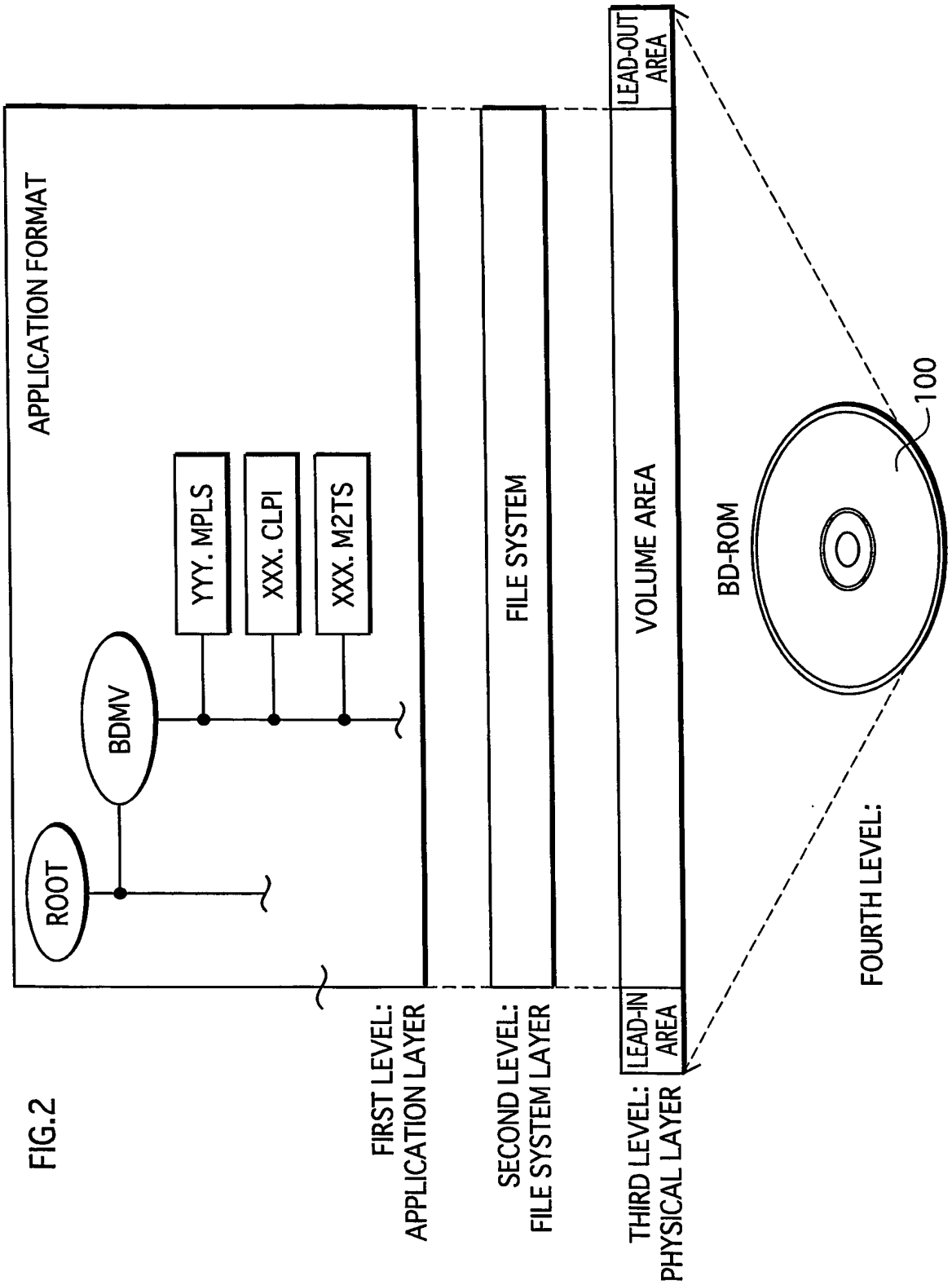
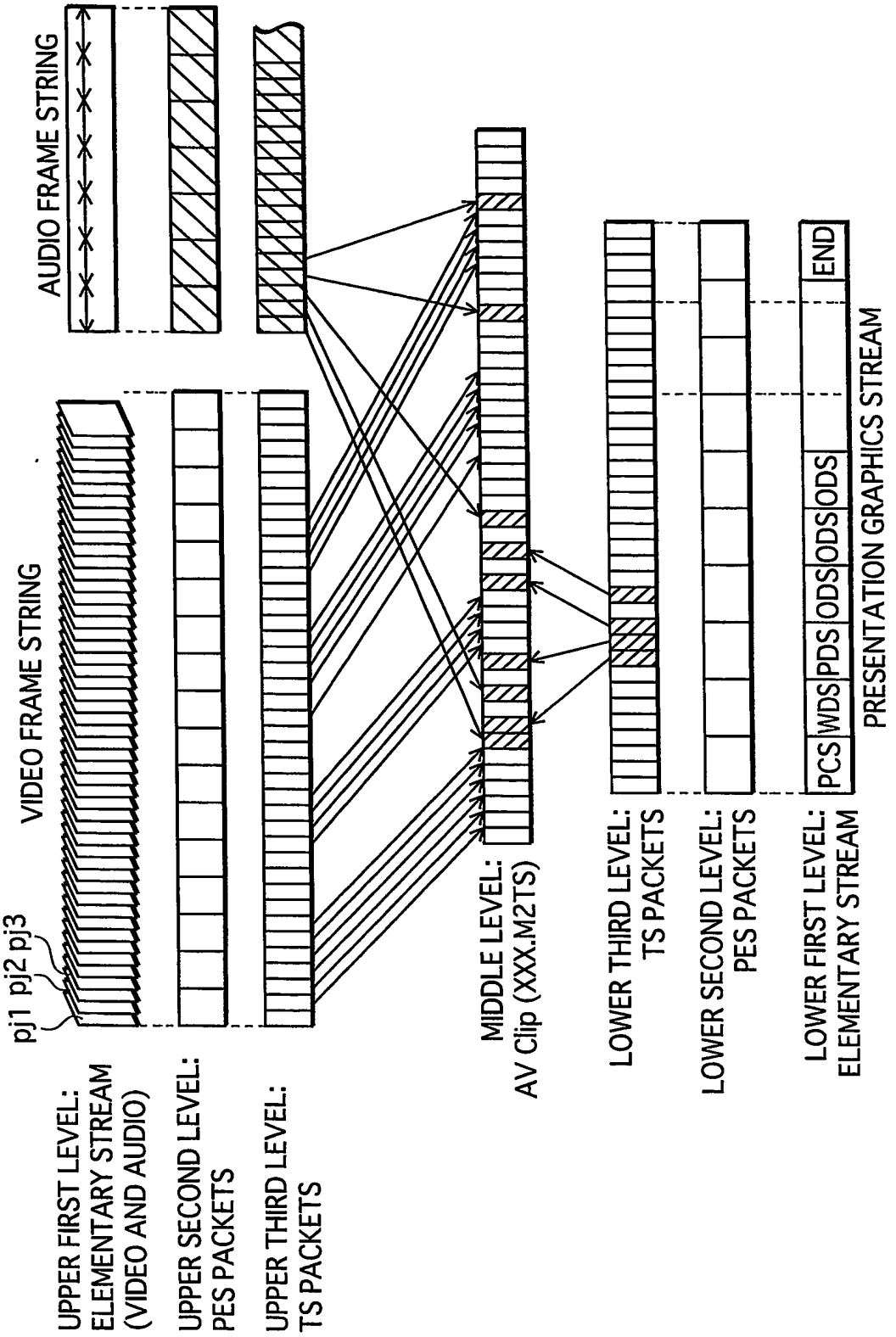

APPLICATION FORMAT
ROOT
BDMV
YYY. MPLS
XXX. CLPI
XXX. M2TS
FILE SYSTEM
VOLUME AREA
LEAD-OUT AREA
LEAD-IN AREA
BD-ROM
100
FIRST LEVEL: APPLICATION LAYER
SECOND LEVEL: FILE SYSTEM LAYER
THIRD LEVEL: PHYSICAL LAYER
FOURTH LEVEL:

FIG.2

FIG.3


AUDIO FRAME STRING
VIDEO FRAME STRING
pj1 pj2 pj3
UPPER FIRST LEVEL: ELEMENTARY STREAM (VIDEO AND AUDIO)
UPPER SECOND LEVEL: PES PACKETS
UPPER THIRD LEVEL: TS PACKETS
MIDDLE LEVEL: AV Clip (XXX.M2TS)
LOWER THIRD LEVEL: TS PACKETS
LOWER SECOND LEVEL: PES PACKETS
LOWER FIRST LEVEL: ELEMENTARY STREAM
PCS
WDS
PDS
ODS
ODS
ODS
END
PRESENTATION GRAPHICS STREAM

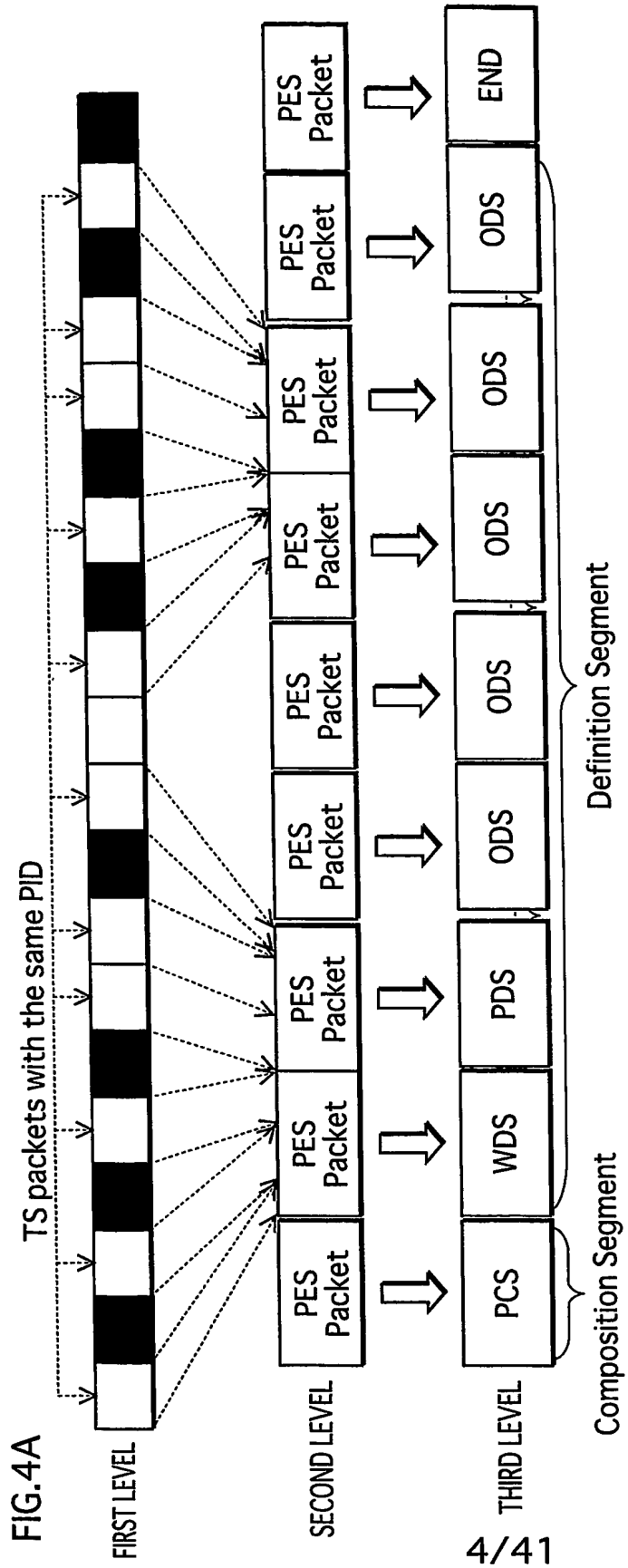

TS packets with the same PID
FIRST LEVEL
SECOND LEVEL
THIRD LEVEL
PES Packet
PCS
WDS
PDS
ODS
END
Composition Segment
Definition Segment

FIG.4A

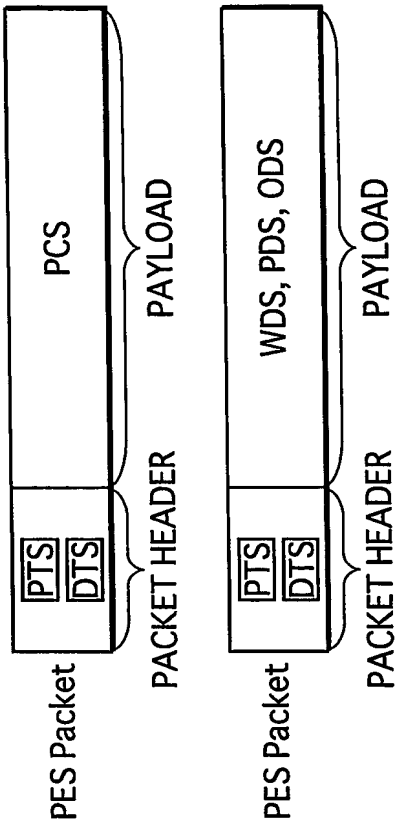

PES Packet
PTS
DTS
PCS
WDS, PDS, ODS
PACKET HEADER
PAYLOAD

FIG.4B

FIG.5

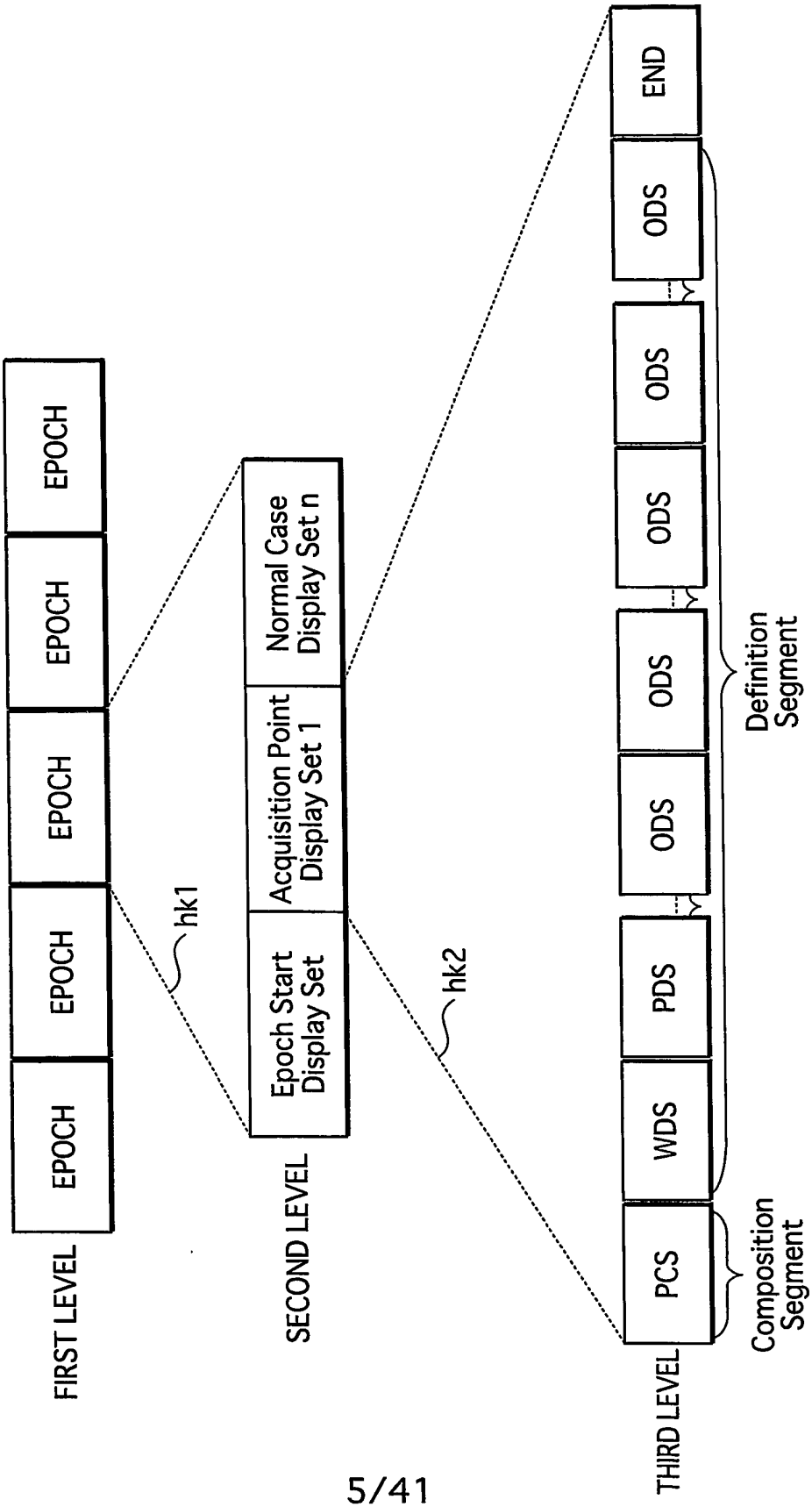

FIRST LEVEL
EPOCH
EPOCH
EPOCH
EPOCH
EPOCH
hk1
SECOND LEVEL
Epoch Start Display Set
Acquisition Point Display Set 1
Normal Case Display Set n
hk2
THIRD LEVEL
PCS
WDS
PDS
ODS
ODS
ODS
ODS
ODS
END
Composition Segment
Definition Segment

FIG.6

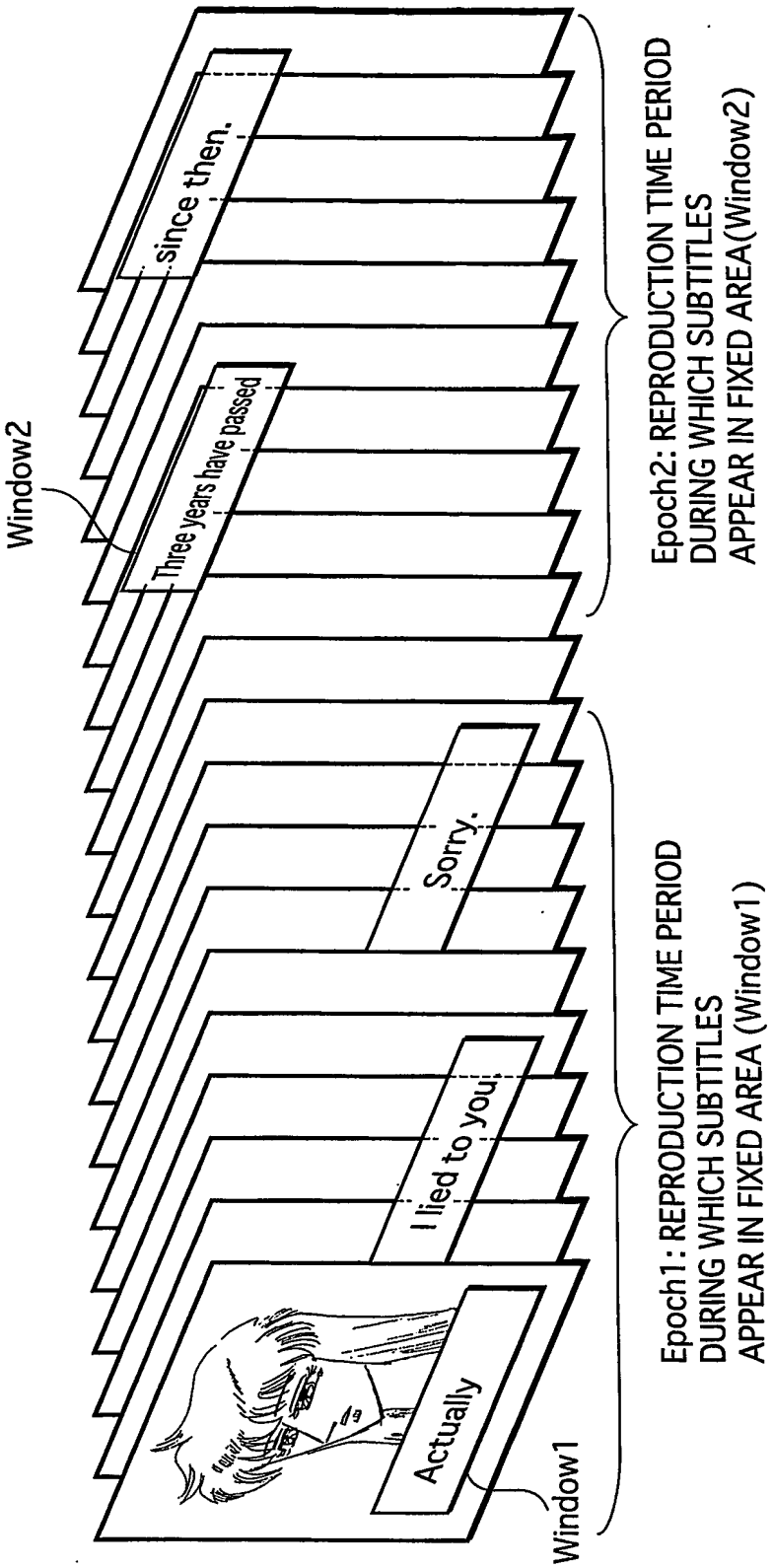

Window2
since then.
Three years have passed
Sorry.
I lied to you.
Actually
Window1
Epoch2: REPRODUCTION TIME PERIOD
DURING WHICH SUBTITLES
APPEAR IN FIXED AREA(Window2)
Epoch1: REPRODUCTION TIME PERIOD
DURING WHICH SUBTITLES
APPEAR IN FIXED AREA (Window1)

FIG.7A

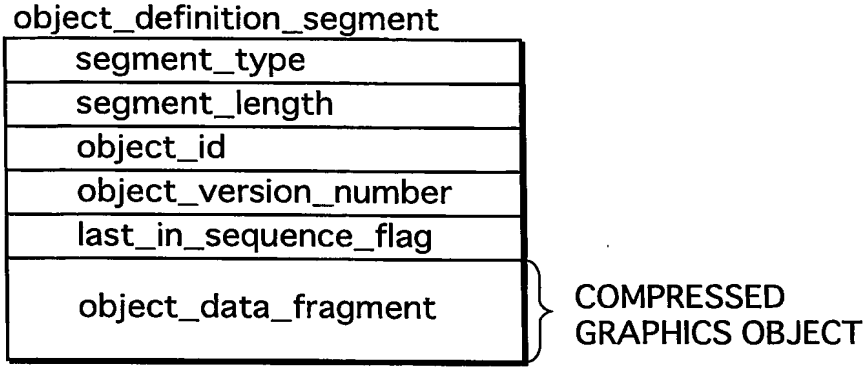

object_definition_segment
segment_type
segment_length
object_id
object_version_number
last_in_sequence_flag
object_data_fragment
COMPRESSED
GRAPHICS OBJECT

FIG.7B

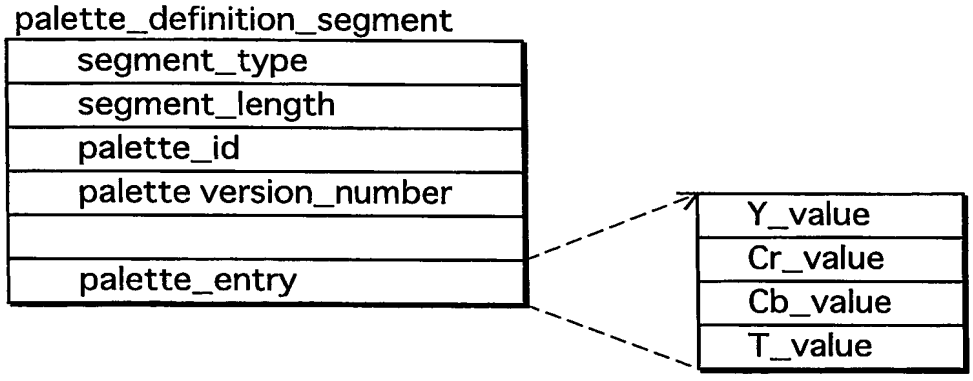

palette_definition_segment
segment_type
segment_length
palette_id
palette version_number
palette_entry
Y_value
Cr_value
Cb_value
T_value

FIG.8A

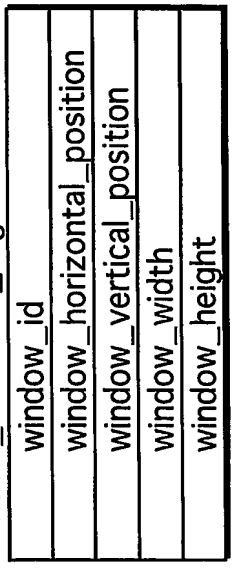

window_definition_segment
window_id
window_horizontal_position
window_vertical_position
window_width
window_height

FIG.8B

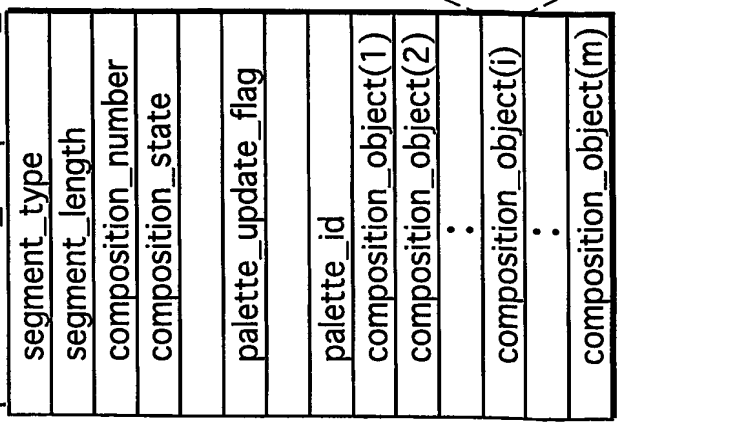

presentation_composition_segment
segment_type
segment_length
composition_number
composition_state
palette_update_flag
palette_id
composition_object(1)
composition_object(2)
composition_object(i)
composition_object(m)
wd1
object_id
window_id
object_cropped_flag
object_horizontal_position
object_vertical_position
cropping_rectangle INFORMATION (1)
cropping_rectangle INFORMATION (2)
cropping_rectangle INFORMATION (i)
cropping_rectangle INFORMATION (n)
wd2
object_cropping_horizontal_position
object_cropping_vertical_position
object_cropping_width
object_cropping_height

FIG.9

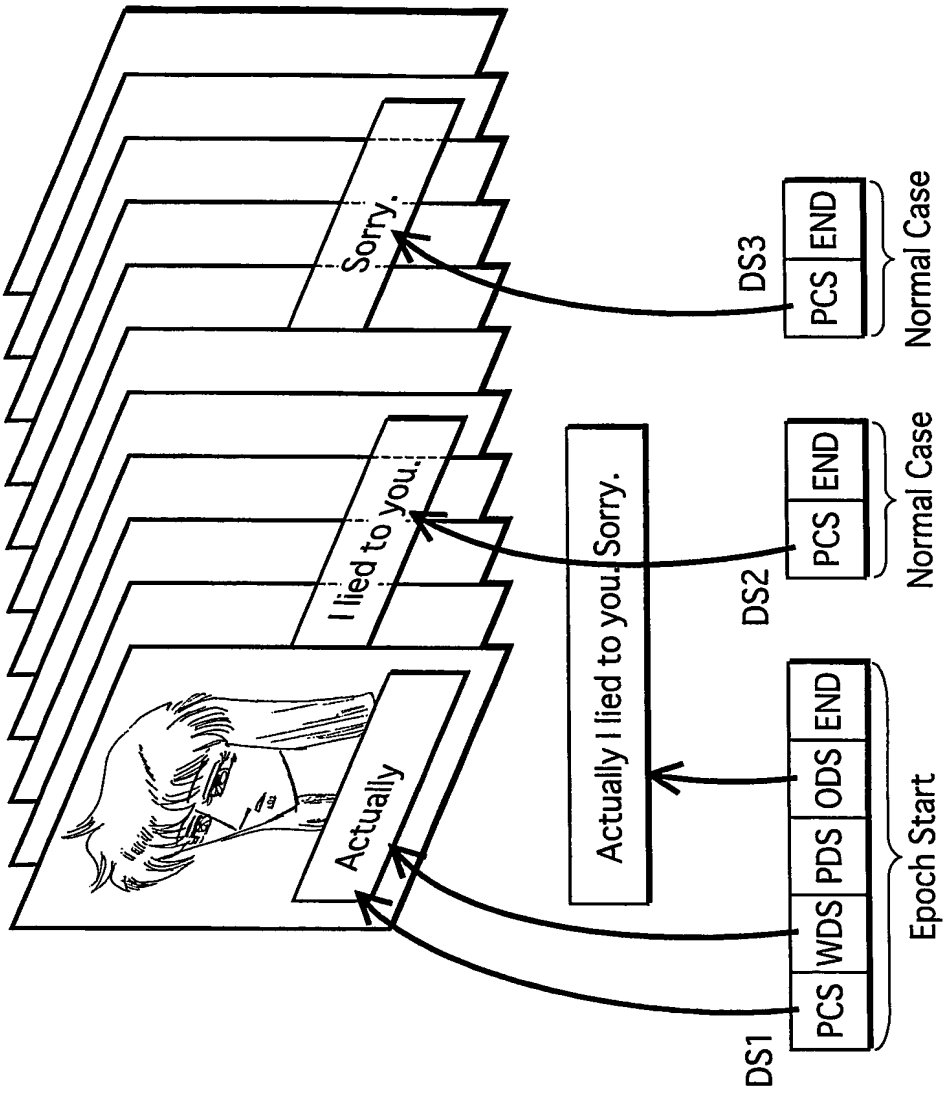

Actually
I lied to you.
Sorry.
Actually I lied to you. Sorry.
DS1
PCS
WDS
PDS
ODS
END
Epoch Start
DS2
PCS
END
Normal Case
DS3
PCS
END
Normal Case

FIG.10

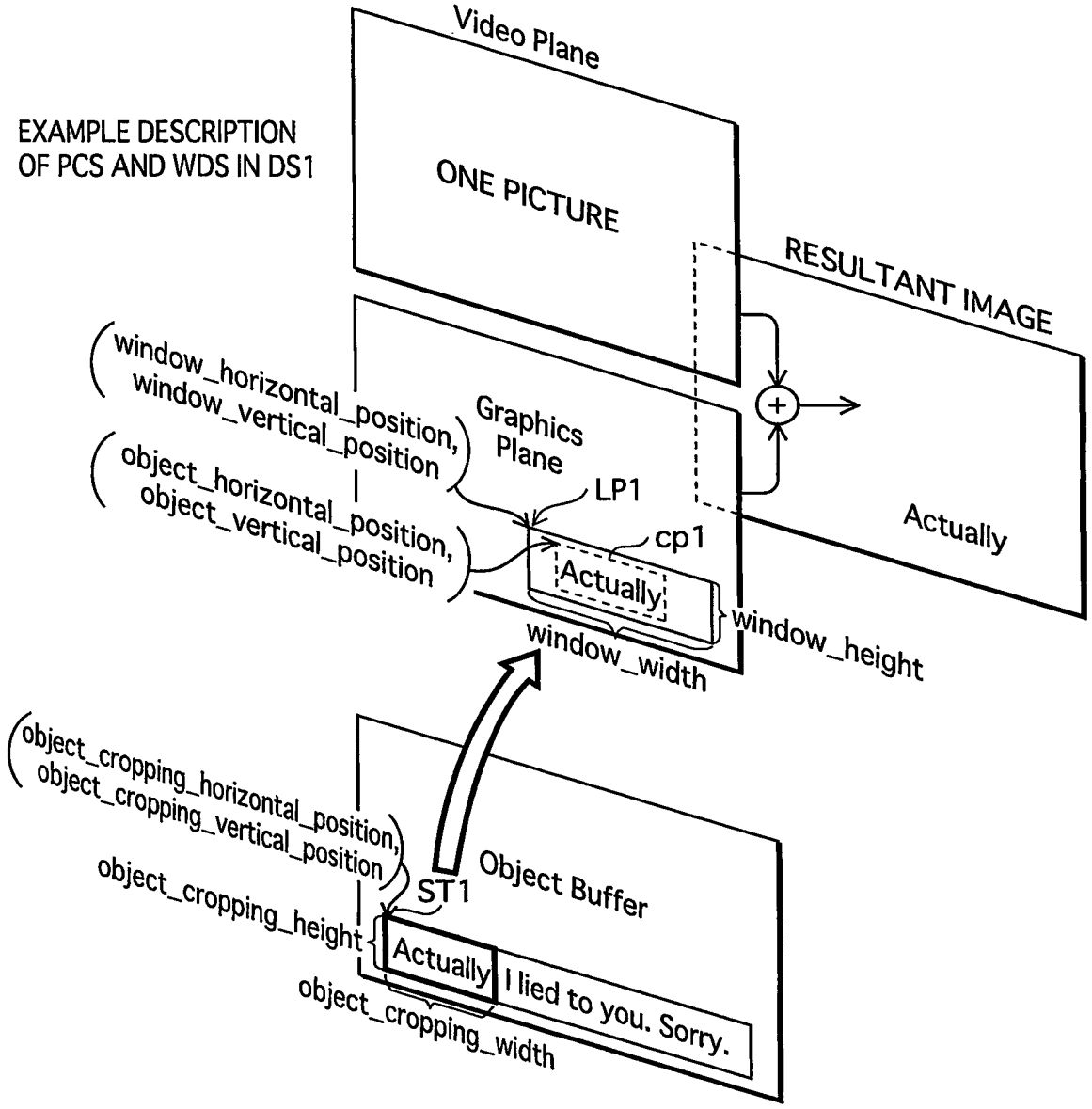

Video Plane
EXAMPLE DESCRIPTION
OF PCS AND WDS IN DS1
ONE PICTURE
RESULTANT IMAGE
window_horizontal_position,
window_vertical_position
Graphics
Plane
object_horizontal_position,
object_vertical_position
LP1
cp1
Actually
Actually
window_width
window_height
object_cropping_horizontal_position,
object_cropping_vertical_position
ST1
Object Buffer
object_cropping_height
Actually
I lied to you. Sorry.
object_cropping_width

FIG.11

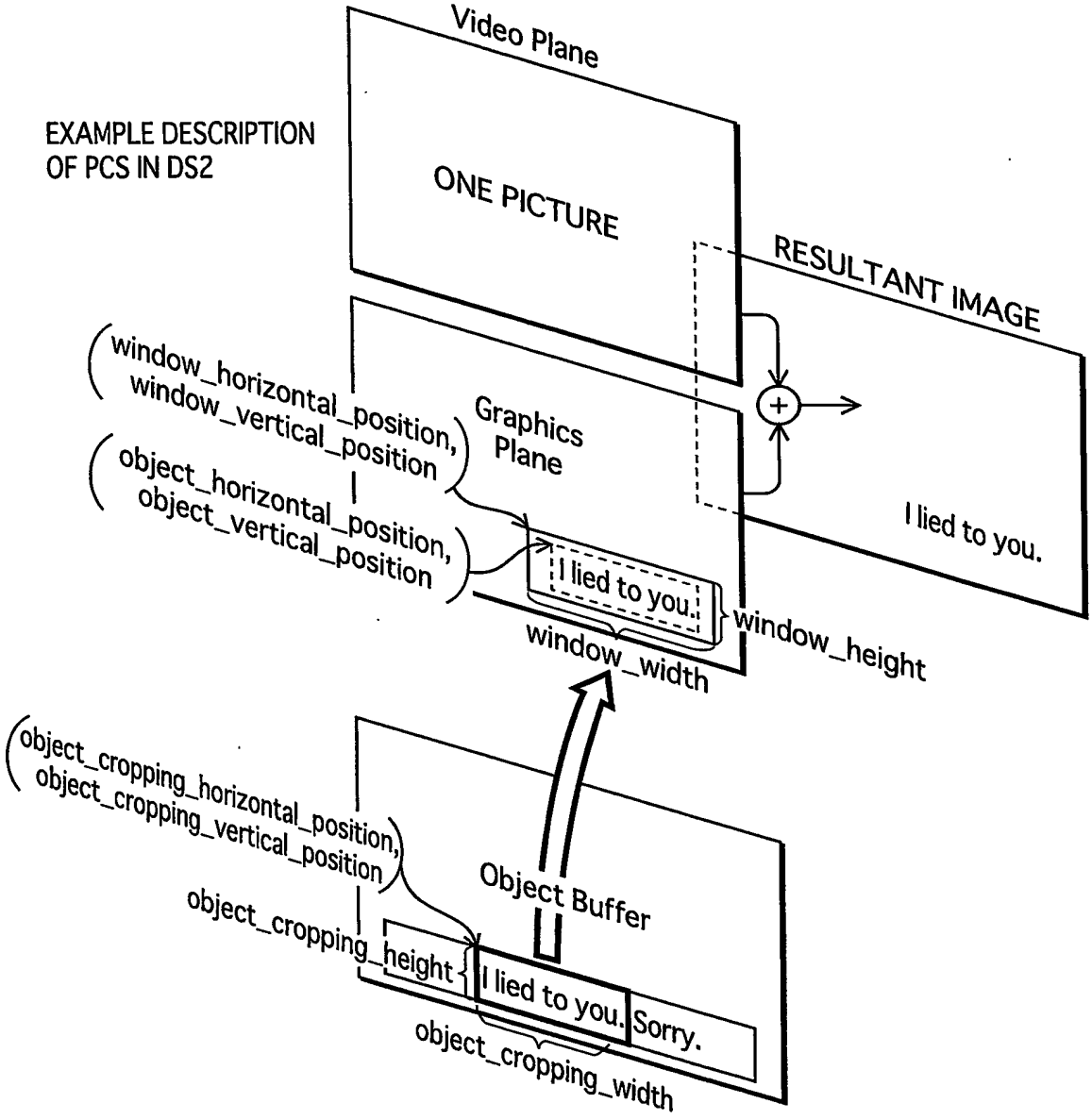

Video Plane
EXAMPLE DESCRIPTION OF PCS IN DS2
ONE PICTURE
RESULTANT IMAGE
window_horizontal_position,
window_vertical_position
Graphics Plane
object_horizontal_position,
object_vertical_position
I lied to you.
I lied to you.
window_width
window_height
object_cropping_horizontal_position,
object_cropping_vertical_position
Object Buffer
object_cropping_height
I lied to you.
Sorry.
object_cropping_width

FIG.12

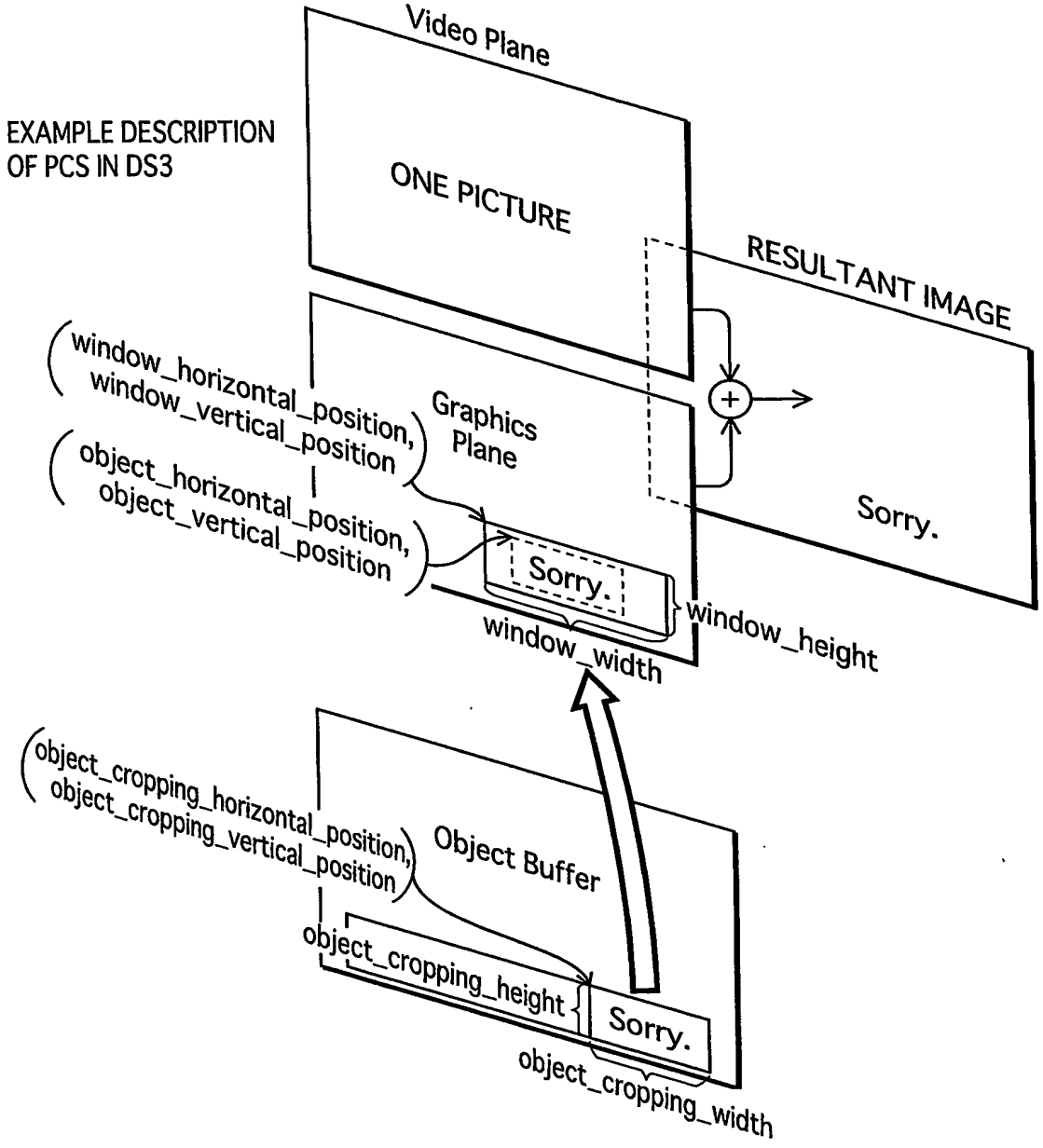

Video Plane
EXAMPLE DESCRIPTION OF PCS IN DS3
ONE PICTURE
RESULTANT IMAGE
window_horizontal_position,
window_vertical_position
Graphics Plane
object_horizontal_position,
object_vertical_position
Sorry.
Sorry.
window_height
window_width
object_cropping_horizontal_position,
object_cropping_vertical_position
Object Buffer
object_cropping_height
Sorry.
object_cropping_width

FIG.13

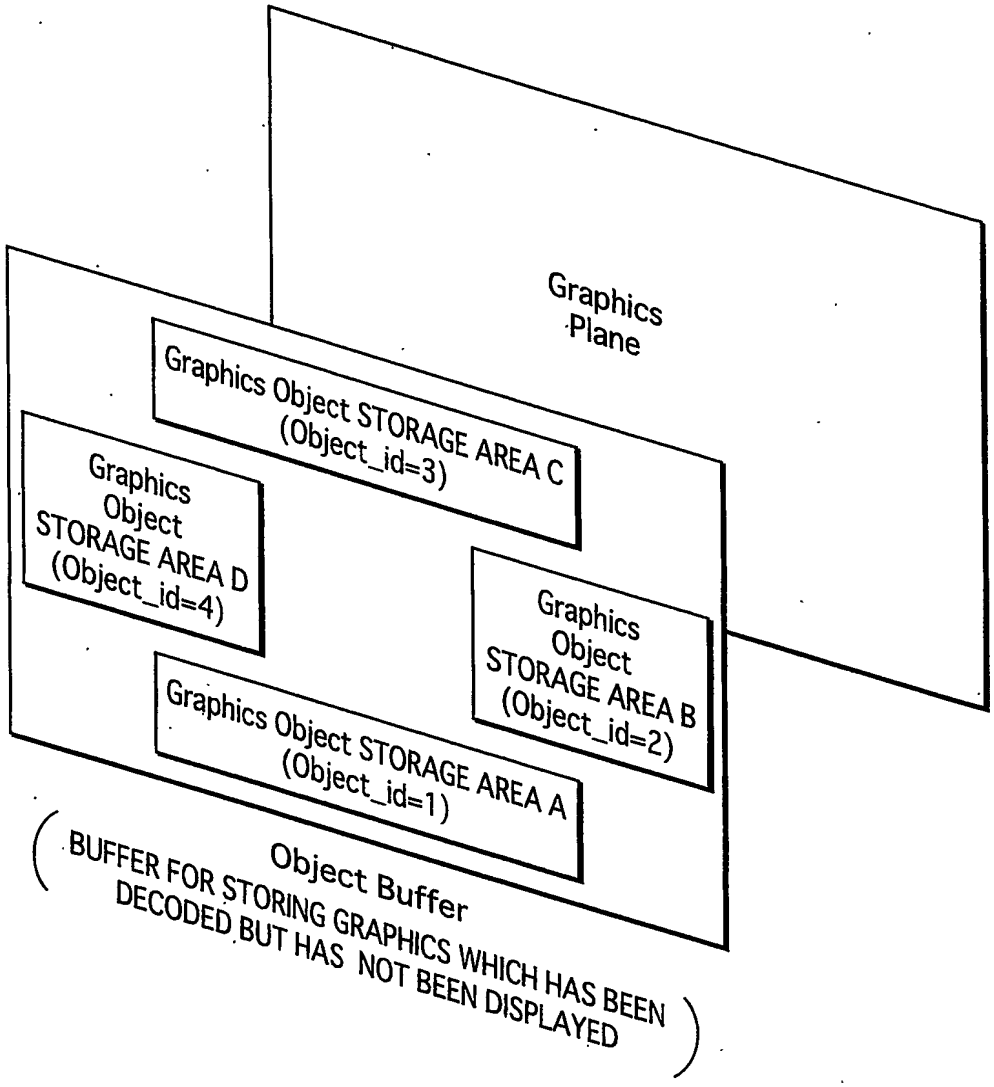

Graphics Plane
Graphics Object STORAGE AREA C (Object_id=3)
Graphics Object STORAGE AREA D (Object_id=4)
Graphics Object STORAGE AREA B (Object_id=2)
Graphics Object STORAGE AREA A (Object_id=1)
Object Buffer
BUFFER FOR STORING GRAPHICS WHICH HAS BEEN DECODED BUT HAS NOT BEEN DISPLAYED

FIG. 14

```
PTS( DSn[PCS)] )>=DTS( DSn[PCS] )+DECODEDURATION( DSn )
Where:
  • DECODEDURATION( DSn ) is calculated as follows:
decode_duration = 0 ;
decode_duration += PLANEINITIALIZATIONTIME( DSn ) ;
if( DSn. PCS. num_of_objects == 2 )
{
    decode_duration += WAIT( DSn, DSn. PCS. OBJ[0], decode_duration ) ;
    if( DSn. PCS. OBJ[0]. window_id == DSn. PCS. OBJ[1]. window_id )
    {
            decode_duration += WAIT( DSn, DSn. PCS. OBJ[1], decode_duration ) ;
            decode_duration += 90000*( SIZE( DSn. PCS. OBJ[0]. window_id )//256*10^6 ) ;
    }
    else
    {
            decode_duration += 90000*( SIZE( DSn. PCS. OBJ[0]. window_id )//256*10^6 ) ;
            decode_duration += WAIT( DSn, DSn. PCS. OBJ[1], decode_duration );
            decode_duration += 90000*( SIZE( DSn. PCS. OBJ[1]. window_id )//256*10^6 ) ;
    }
}
else if( DSn. PCS. num_of_objects ==1 )
{
    decode_duration += WAIT( DSn, DSn. PCS. OBJ[0], decode_duration ) ;
    decode_duration += 90000*( SIZE( DSn. PCS. OBJ[0]. window_id )//256*10^6 ) ;
}
return decode_duration ;

  • PLANEINITIALIZATIONTIME( DSn ) is calculated as follows:
initialize_duration=0 ;
if( DSn. PCS. composition_state= = EPOCH_START )
{
  initialize_duration = 90000*( 8*video_width*video_height//256*10^6) ;
}

else
 {
    for( i=0 ; i < WDS. num_windows ; i++ )
    {
            if( EMPTY(DSn.WDS.WIN[i],DSn ) )
                    initialize_duration += 90000*( SIZE( DSn. WDS. WIN[i] )//256*10^6) ;
    }
}
return initialize_duration ;

  • WAIT( DSn, OBJ, current_duration ) is calculated as follows:
wait_duration = 0 ;
if( EXISTS( OBJ. object_id, DSn ) )
{
    object_definition_ready_time = PTS( GET( OBJ. object_id. DSn ) ) ;
    current_time = DTS( DSn. PCS )+current_duration ;
    if( current_time < object_definition_ready_time )
            wait_duration += object_definition_ready_time - current_time ) ;
}
return wait_duration ;
```

FIG.15

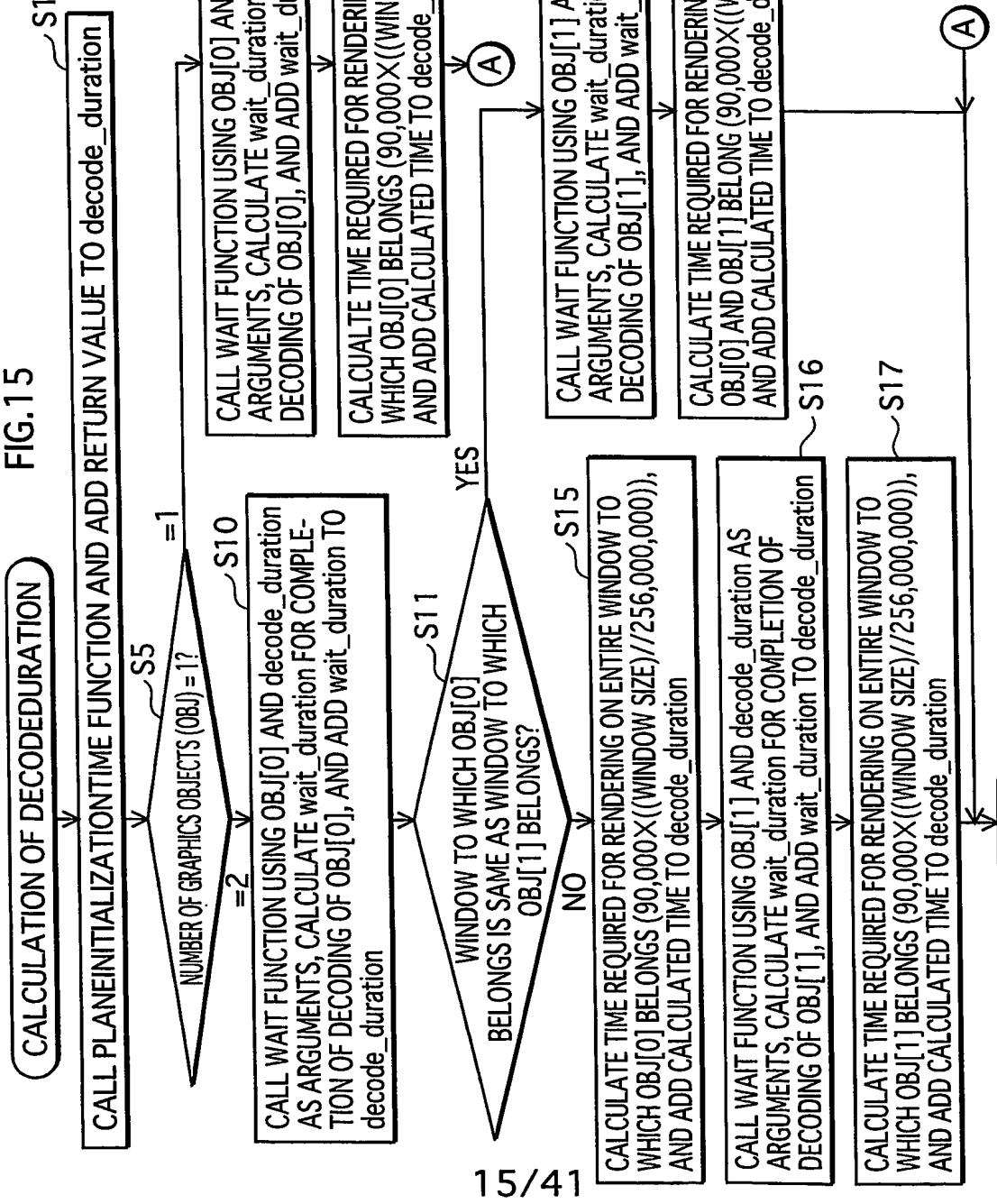

CALCULATION OF DECODEDURATION
S1
CALL PLANEINITIALIZATIONTIME FUNCTION AND ADD RETURN VALUE TO decode_duration
S5
NUMBER OF GRAPHICS OBJECTS (OBJ) = 1?
=1
=2
S6
CALL WAIT FUNCTION USING OBJ[0] AND decode_duration AS ARGUMENTS, CALCULATE wait_duration FOR COMPLETION OF DECODING OF OBJ[0], AND ADD wait_duration TO decode_duration
S9
CALCUALTE TIME REQUIRED FOR RENDERING ON ENTIRE WINDOW TO WHICH OBJ[0] BELONGS (90,000×((WINDOW SIZE)//256,000,000)), AND ADD CALCULATED TIME TO decode_duration
S10
CALL WAIT FUNCTION USING OBJ[0] AND decode_duration AS ARGUMENTS, CALCULATE wait_duration FOR COMPLETION OF DECODING OF OBJ[0], AND ADD wait_duration TO decode_duration
S11
WINDOW TO WHICH OBJ[0] BELONGS IS SAME AS WINDOW TO WHICH OBJ[1] BELONGS?
YES
NO
A
S12
CALL WAIT FUNCTION USING OBJ[1] AND decode_duration AS ARGUMENTS, CALCULATE wait_duration FOR COMPLETION OF DECODING OF OBJ[1], AND ADD wait_duration TO decode_duration
S13
CALCULATE TIME REQUIRED FOR RENDERING ON ENTIRE WINDOW TO WHICH OBJ[0] AND OBJ[1] BELONG (90,000×((WINDOW SIZE)//256,000,000)), AND ADD CALCULATED TIME TO decode_duration
S15
CALCULATE TIME REQUIRED FOR RENDERING ON ENTIRE WINDOW TO WHICH OBJ[0] BELONGS (90,000×((WINDOW SIZE)//256,000,000)), AND ADD CALCULATED TIME TO decode_duration
S16
CALL WAIT FUNCTION USING OBJ[1] AND decode_duration AS ARGUMENTS, CALCULATE wait_duration FOR COMPLETION OF DECODING OF OBJ[1], AND ADD wait_duration TO decode_duration
S17
CALCULATE TIME REQUIRED FOR RENDERING ON ENTIRE WINDOW TO WHICH OBJ[1] BELONGS (90,000×((WINDOW SIZE)//256,000,000)), AND ADD CALCULATED TIME TO decode_duration
A
END

FIG.16A

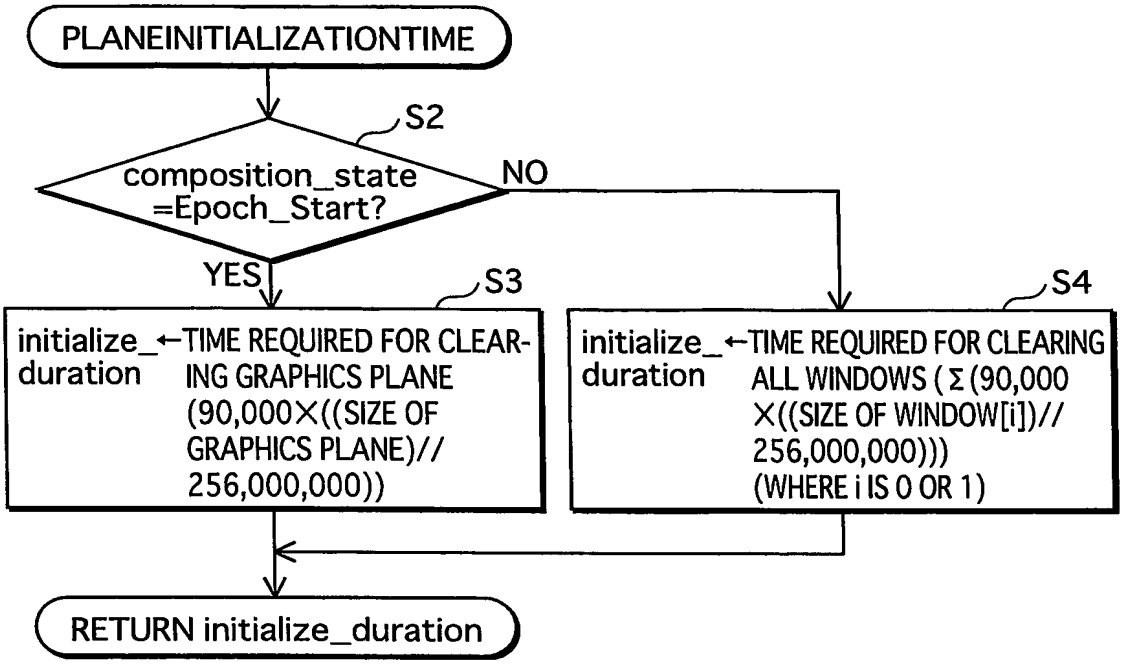


FIG.16B

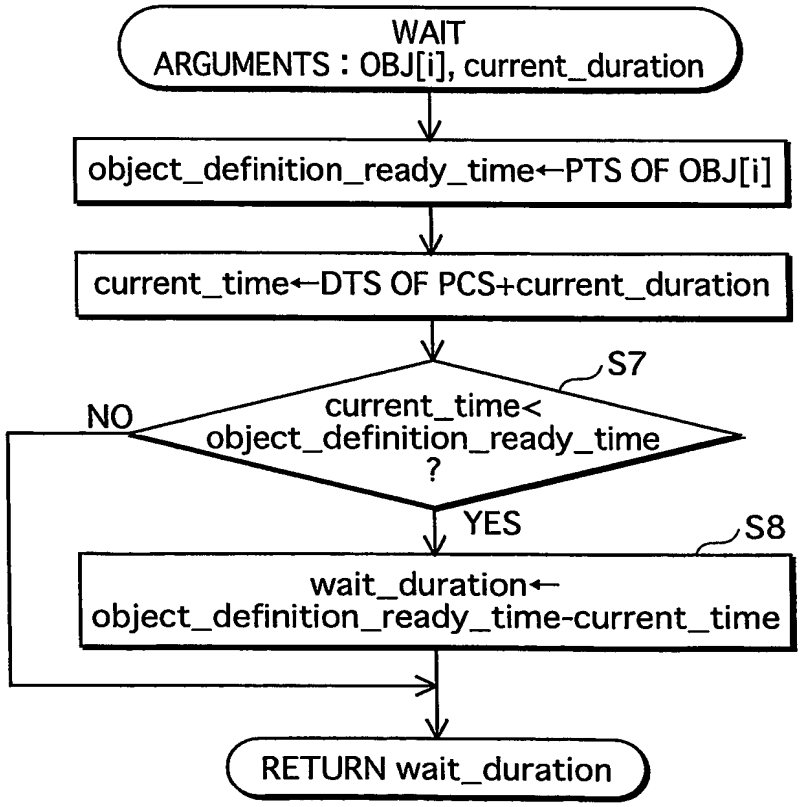


FIG.17A

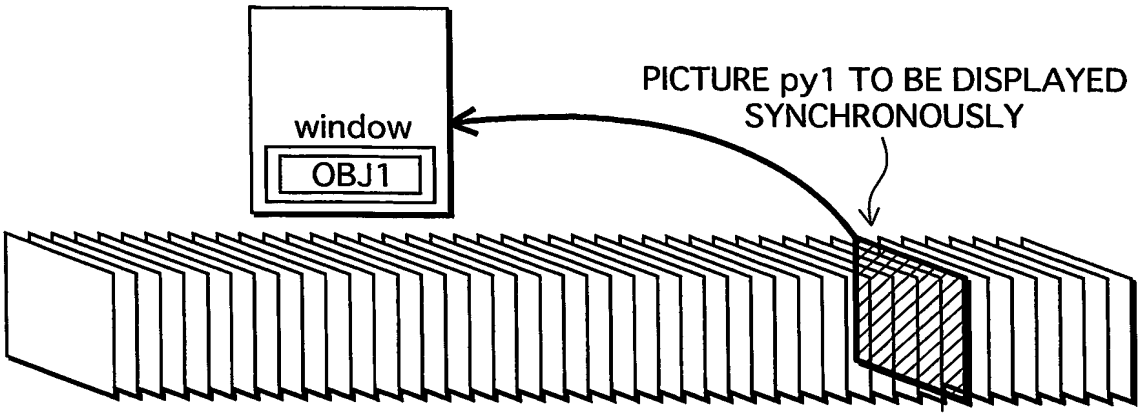


FIG.17B

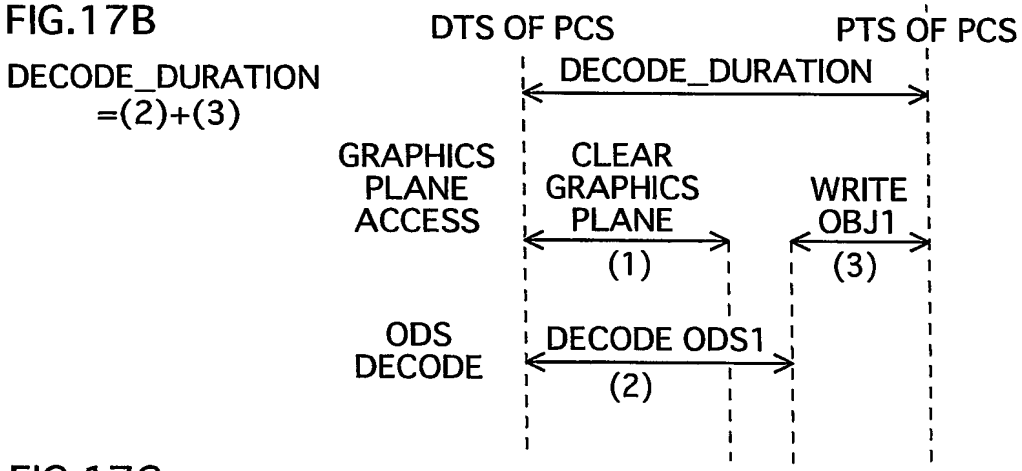


FIG.17C

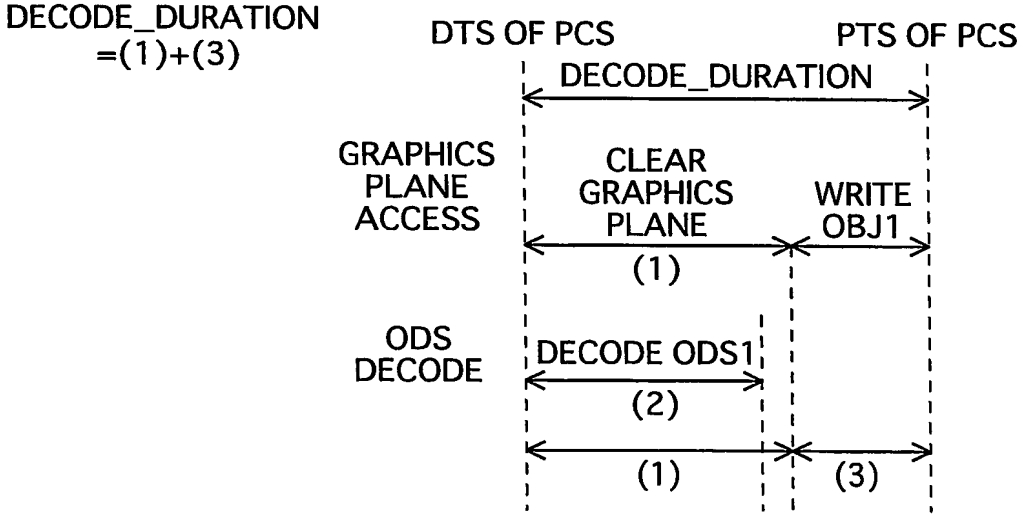


FIG.18A

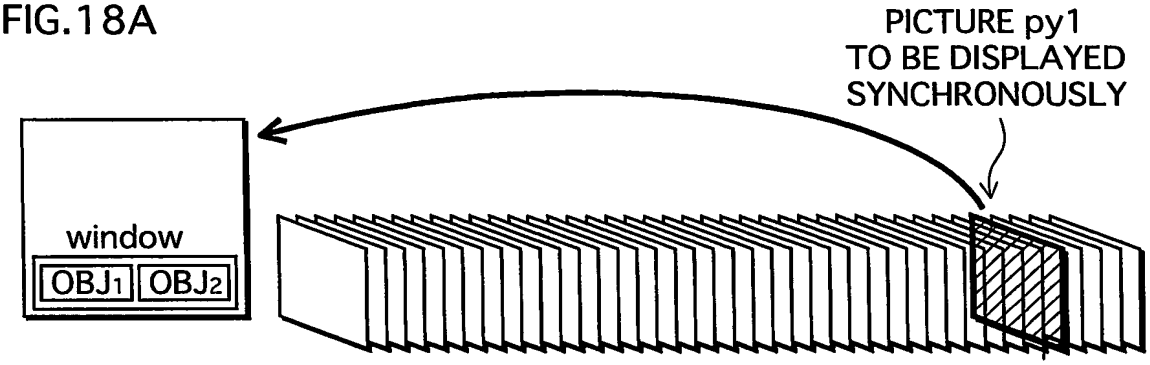


FIG.18B

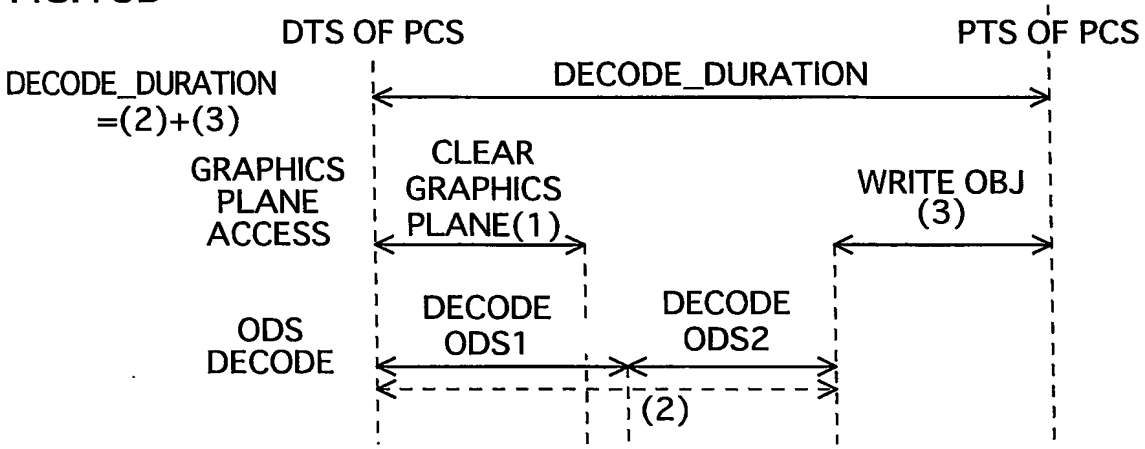
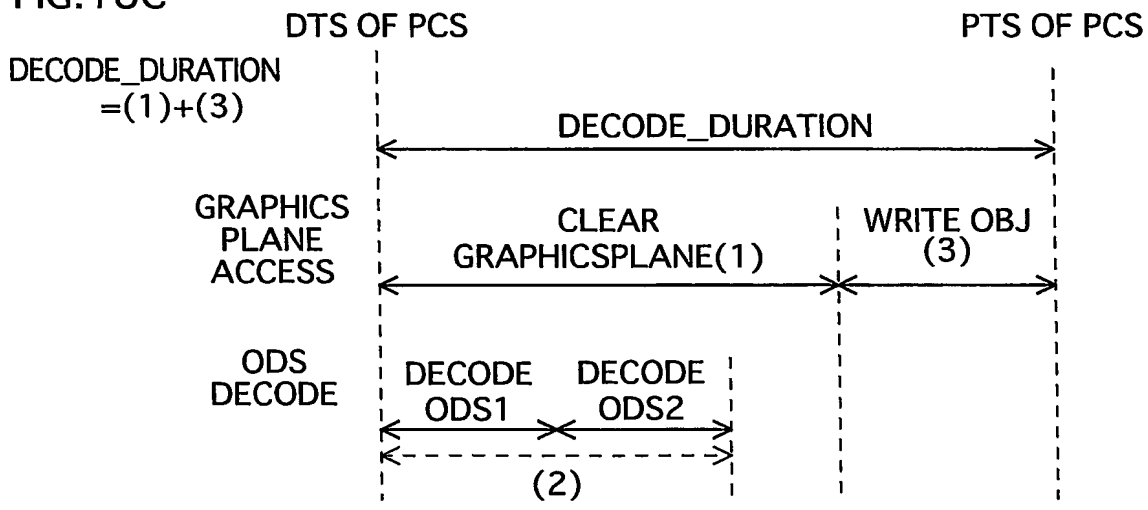


FIG.18C



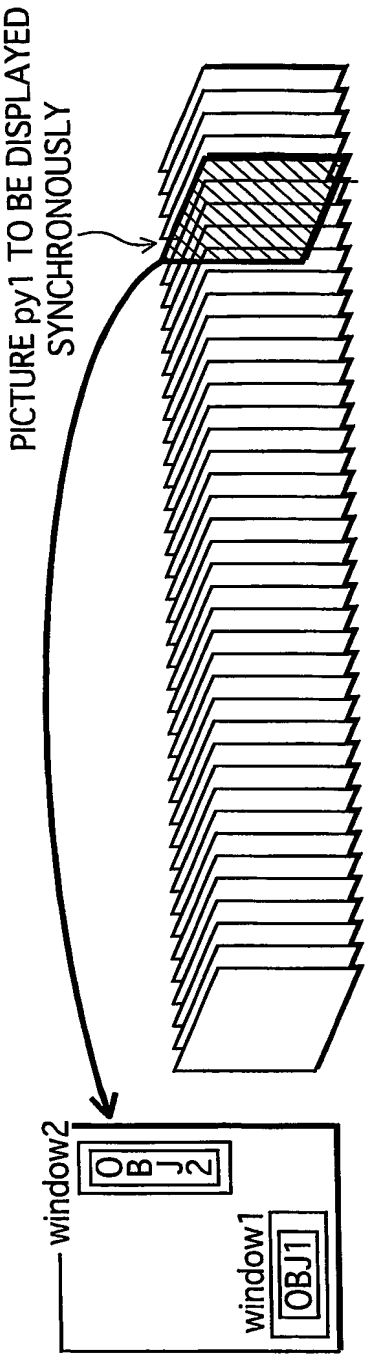


FIG.19A

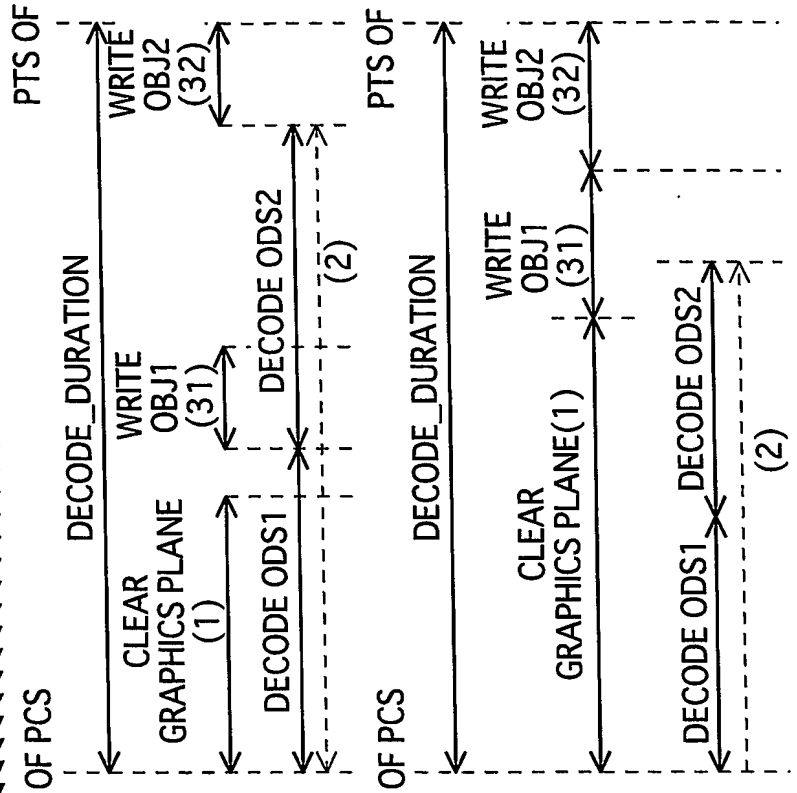


FIG.19B

DECODE_DURATION
=(2)+(32)

FIG.19C

DECODE_DURATION
=(1)+(31)+(32)

FIG.20

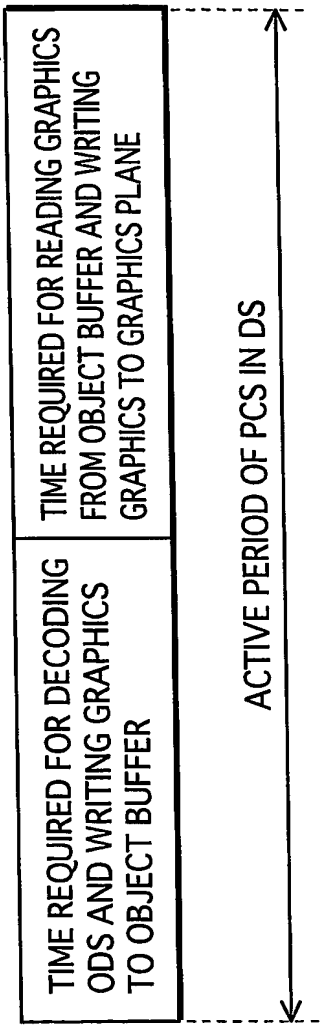

TIME REQUIRED FOR DECODING ODS AND WRITING GRAPHICS TO OBJECT BUFFER
TIME REQUIRED FOR READING GRAPHICS FROM OBJECT BUFFER AND WRITING GRAPHICS TO GRAPHICS PLANE
ACTIVE PERIOD OF PCS IN DS

FIG.21

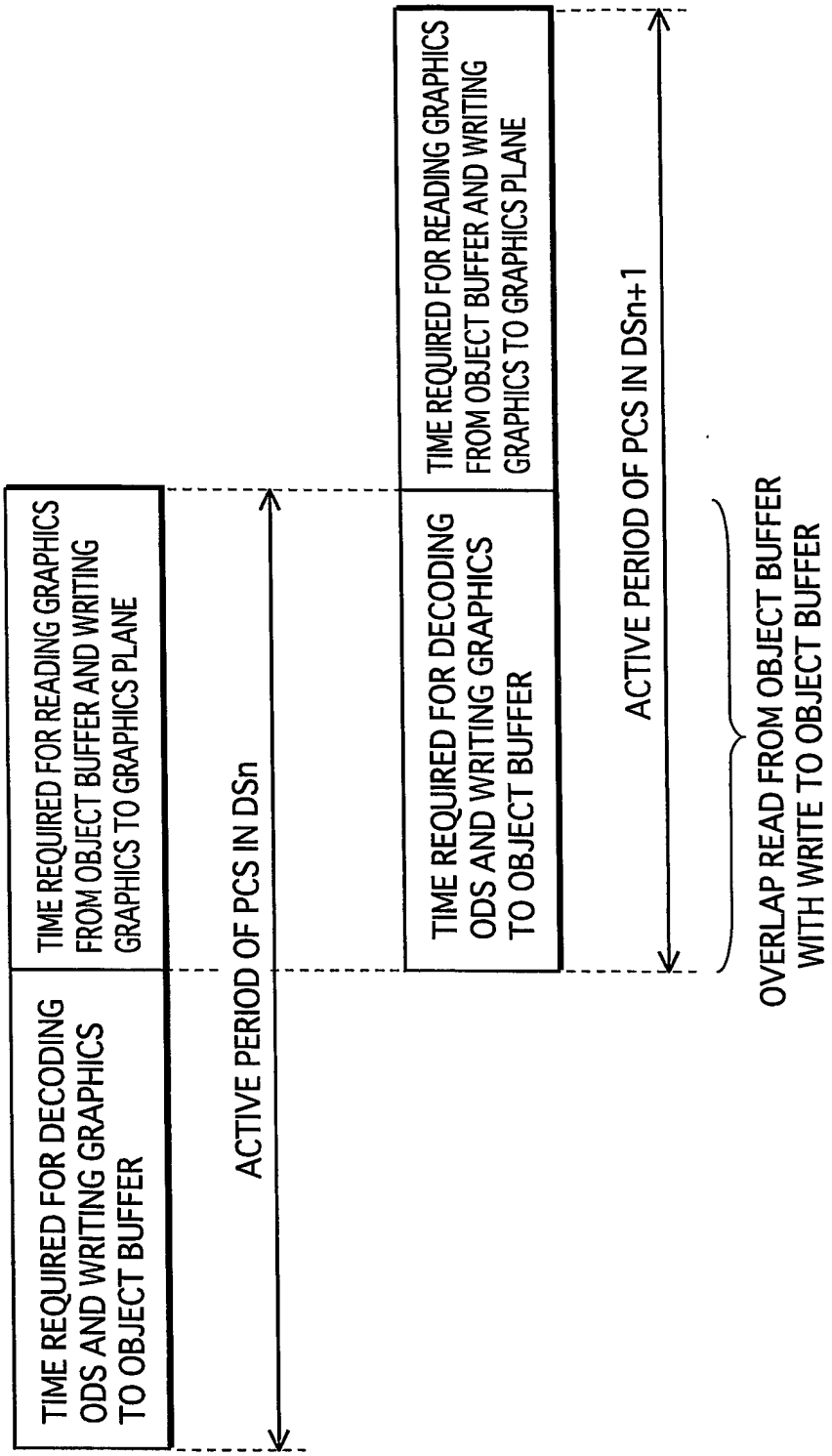

TIME REQUIRED FOR DECODING ODS AND WRITING GRAPHICS TO OBJECT BUFFER
TIME REQUIRED FOR READING GRAPHICS FROM OBJECT BUFFER AND WRITING GRAPHICS TO GRAPHICS PLANE
ACTIVE PERIOD OF PCS IN DSn
TIME REQUIRED FOR DECODING ODS AND WRITING GRAPHICS TO OBJECT BUFFER
TIME REQUIRED FOR READING GRAPHICS FROM OBJECT BUFFER AND WRITING GRAPHICS TO GRAPHICS PLANE
ACTIVE PERIOD OF PCS IN DSn+1
OVERLAP READ FROM OBJECT BUFFER WITH WRITE TO OBJECT BUFFER

FIG.22

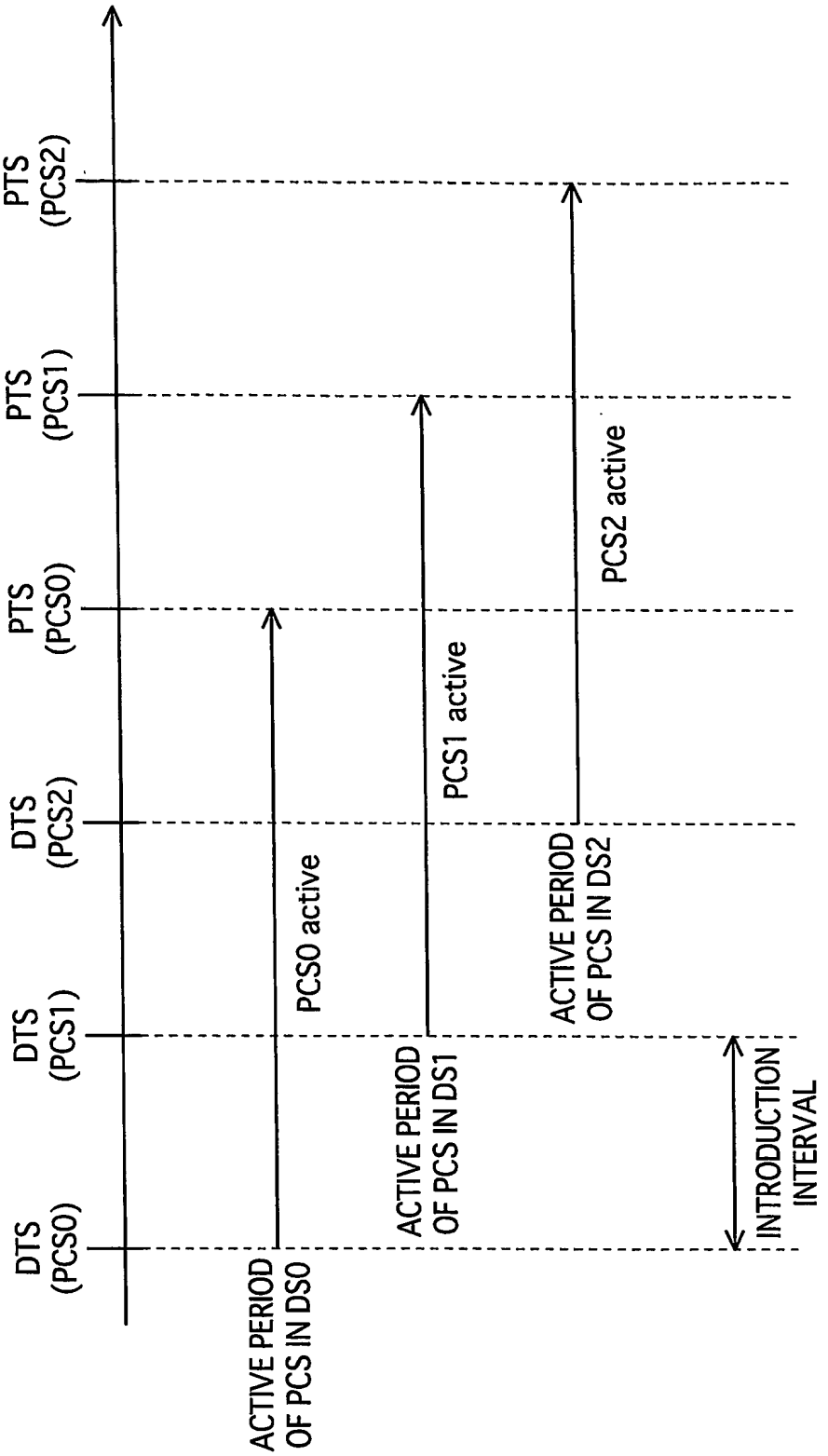

DTS (PCS0)
DTS (PCS1)
DTS (PCS2)
PTS (PCS0)
PTS (PCS1)
PTS (PCS2)
ACTIVE PERIOD OF PCS IN DS0
PCS0 active
ACTIVE PERIOD OF PCS IN DS1
PCS1 active
ACTIVE PERIOD OF PCS IN DS2
PCS2 active
INTRODUCTION INTERVAL

FIG.23

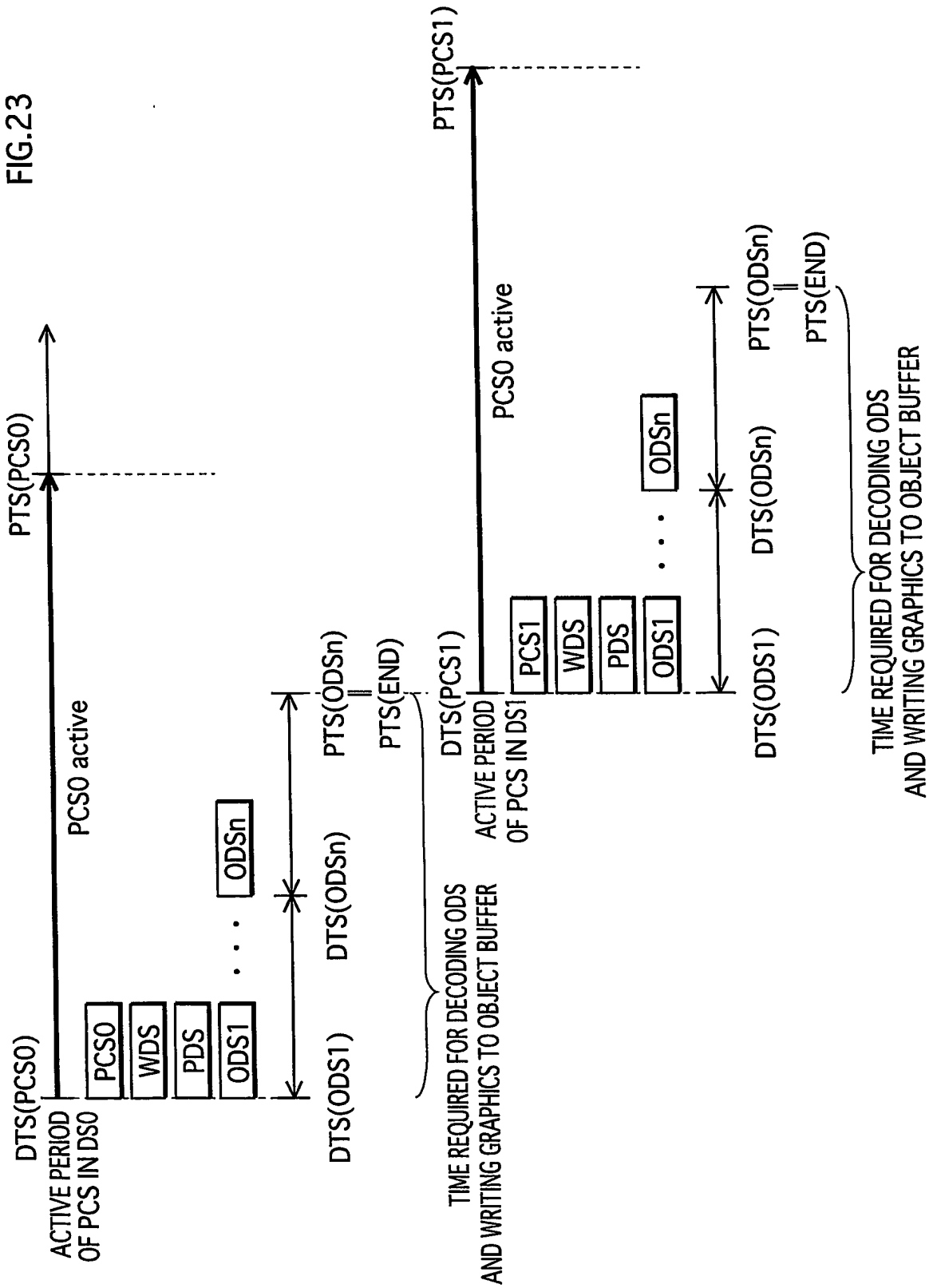
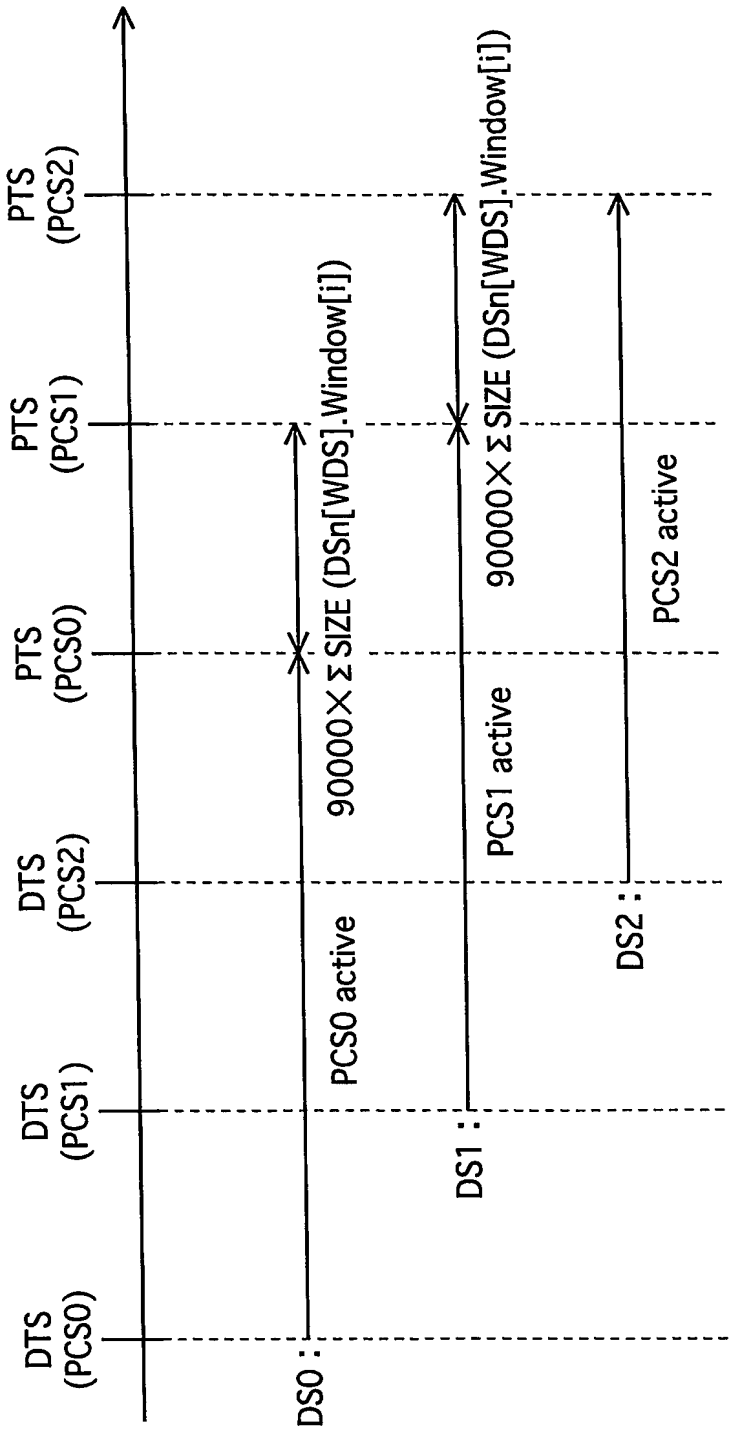

PTS(PCS0)
PCS0 active
DTS(PCS0)
ACTIVE PERIOD OF PCS IN DS0
PCS0
WDS
PDS
ODS1
ODSn
DTS(ODS1)
DTS(ODSn)
PTS(ODSn)
PTS(END)
TIME REQUIRED FOR DECODING ODS AND WRITING GRAPHICS TO OBJECT BUFFER
PTS(PCS1)
PCS0 active
DTS(PCS1)
ACTIVE PERIOD OF PCS IN DS1
PCS1
WDS
PDS
ODS1
ODSn
DTS(ODS1)
DTS(ODSn)
PTS(ODSn)
PTS(END)
TIME REQUIRED FOR DECODING ODS AND WRITING GRAPHICS TO OBJECT BUFFER

FIG.24


PTS (PCS2)
PTS (PCS1)
PTS (PCS0)
DTS (PCS2)
DTS (PCS1)
DTS (PCS0)
DS0
DS1
DS2
90000× Σ SIZE (DSn[WDS].Window[i])
90000× Σ SIZE (DSn[WDS].Window[i])
PCS0 active
PCS1 active
PCS2 active

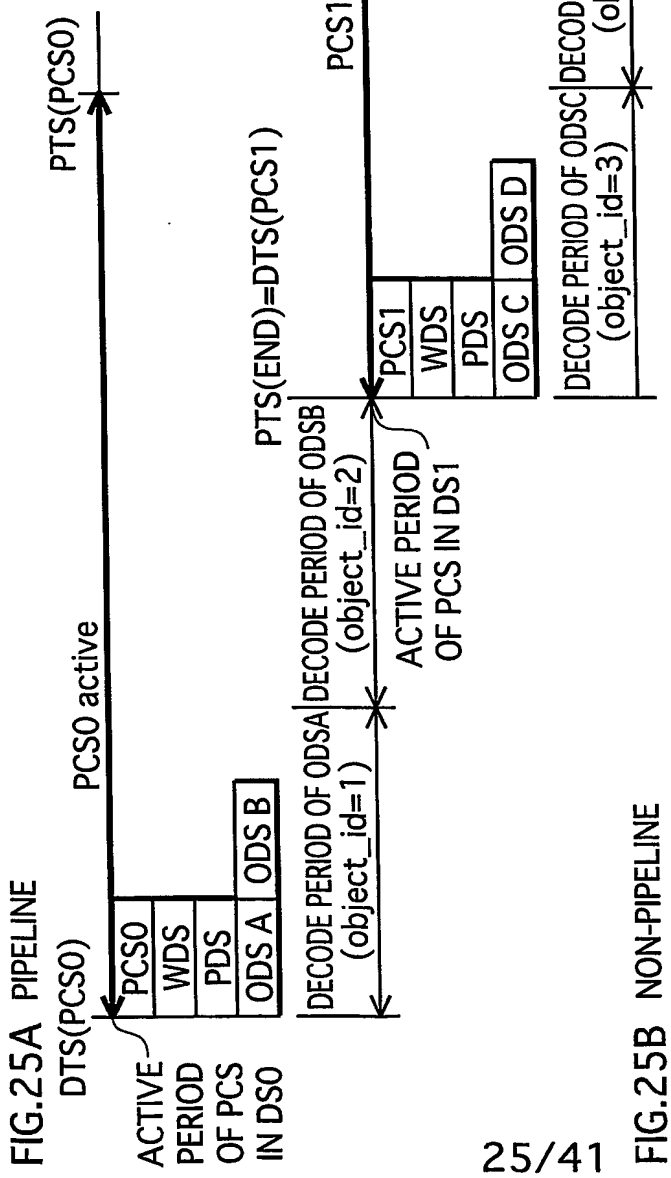


FIG.25A PIPELINE
DTS(PCS0)
PTS(PCS0)
PCS0 active
ACTIVE PERIOD OF PCS IN DS0
PCS0
WDS
PDS
ODS A
ODS B
DECODE PERIOD OF ODSA (object_id=1)
DECODE PERIOD OF ODSB (object_id=2)
PTS(END)=DTS(PCS1)
PTS(PCS1)
PCS1 active
ACTIVE PERIOD OF PCS IN DS1
PCS1
WDS
PDS
ODS C
ODS D
DECODE PERIOD OF ODSC (object_id=3)
DECODE PERIOD OF ODSD (object_id=4)

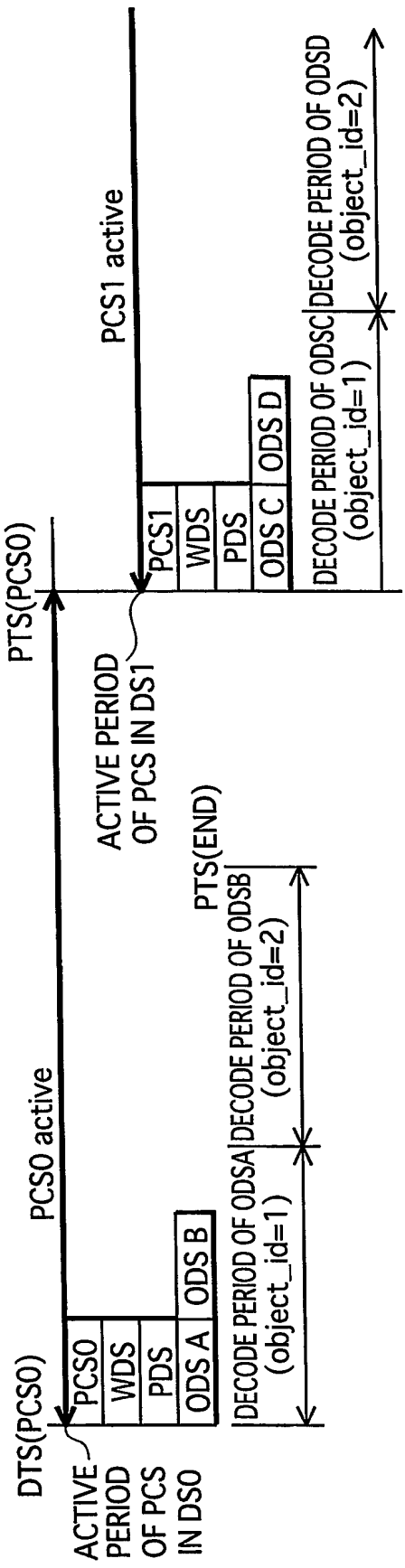


FIG.25B NON-PIPELINE
DTS(PCS0)
PTS(PCS0)
PCS0 active
ACTIVE PERIOD OF PCS IN DS0
PCS0
WDS
PDS
ODS A
ODS B
DECODE PERIOD OF ODSA (object_id=1)
DECODE PERIOD OF ODSB (object_id=2)
PTS(END)
PCS1 active
ACTIVE PERIOD OF PCS IN DS1
PCS1
WDS
PDS
ODS C
ODS D
DECODE PERIOD OF ODSC (object_id=1)
DECODE PERIOD OF ODSD (object_id=2)

FIG.26

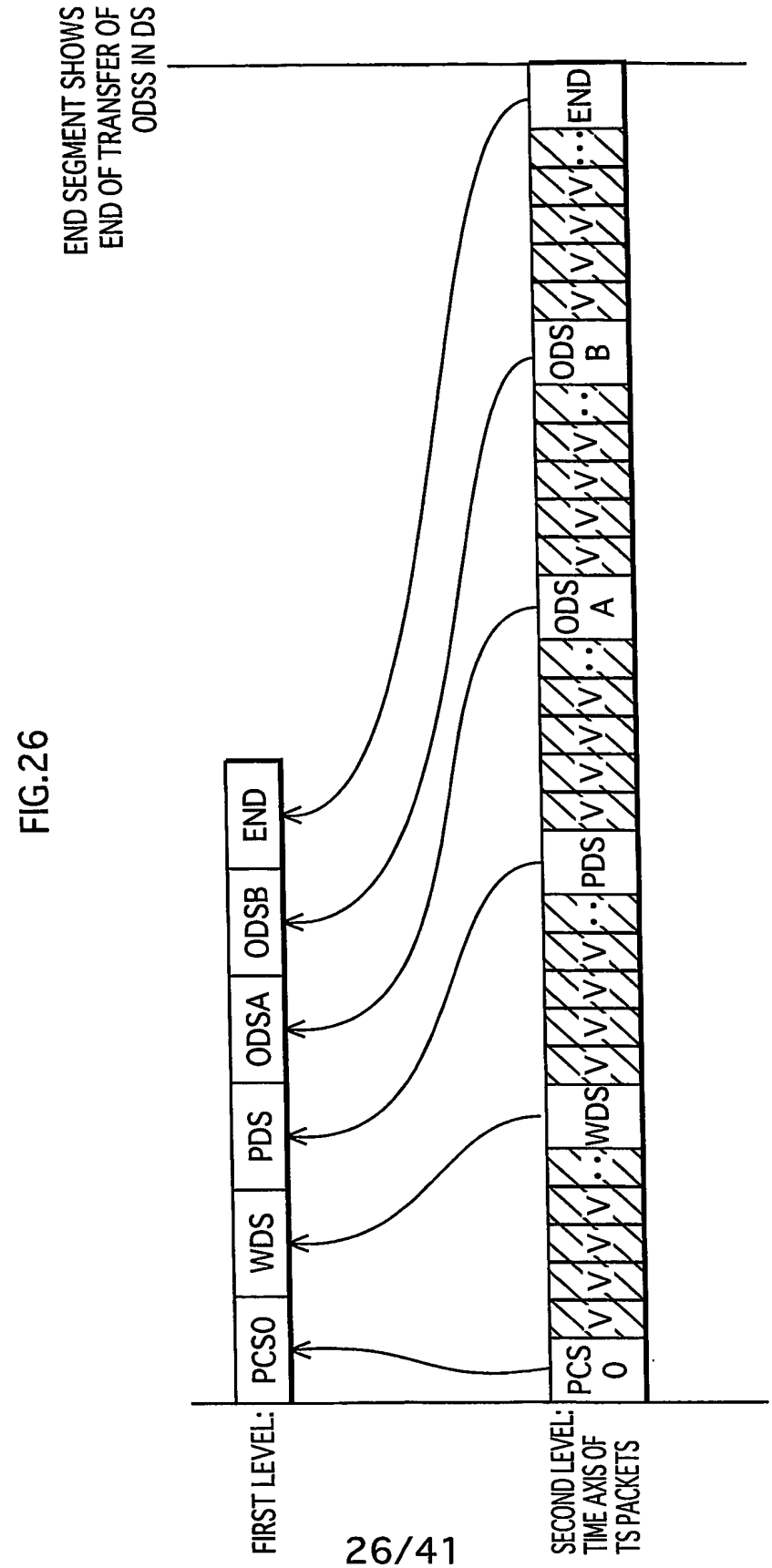

END SEGMENT SHOWS END OF TRANSFER OF ODSS IN DS
FIRST LEVEL:
PCS0
WDS
PDS
ODSA
ODSB
END
SECOND LEVEL: TIME AXIS OF TS PACKETS
PCS 0
WDS
PDS
ODS A
ODS B
END

FIG.27A SCREEN COMPOSITION

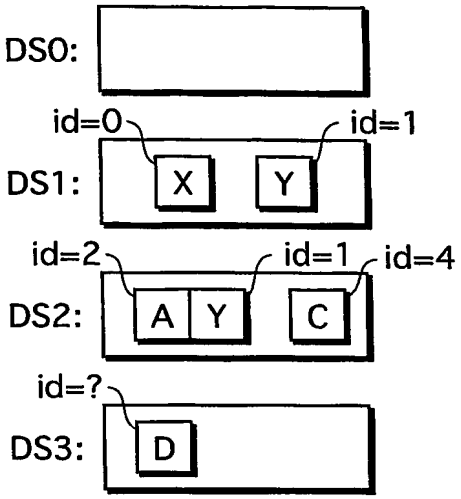


FIG.27B ACTIVE PERIOD OVERLAPPING AND ODS TRANSFER

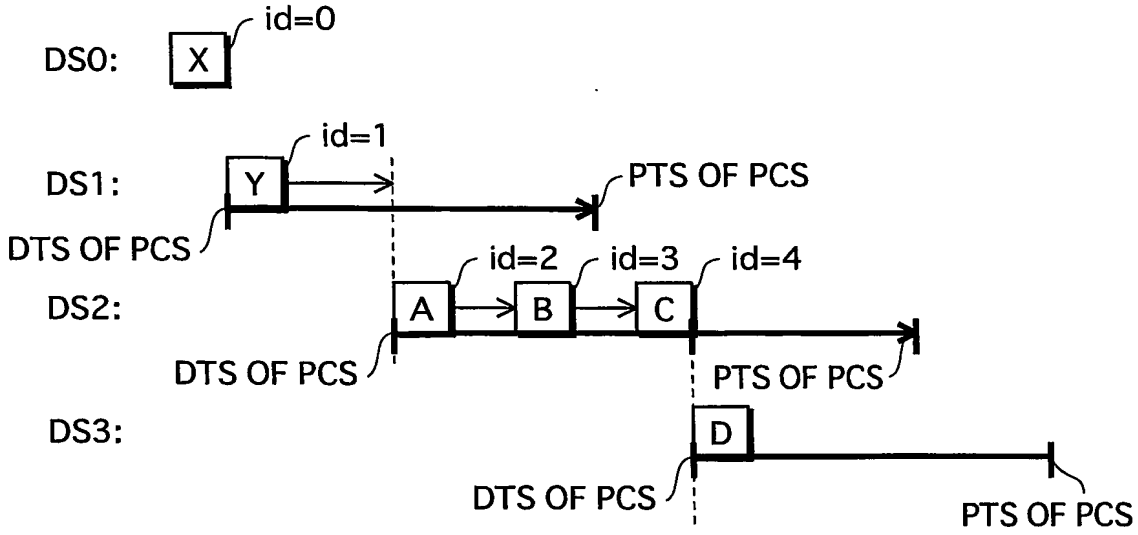


FIG.27C ARRANGEMENT IN OBJECT BUFFER

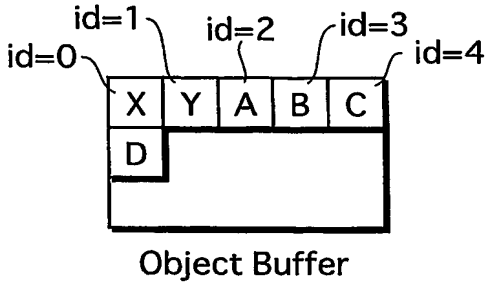


FIG.28

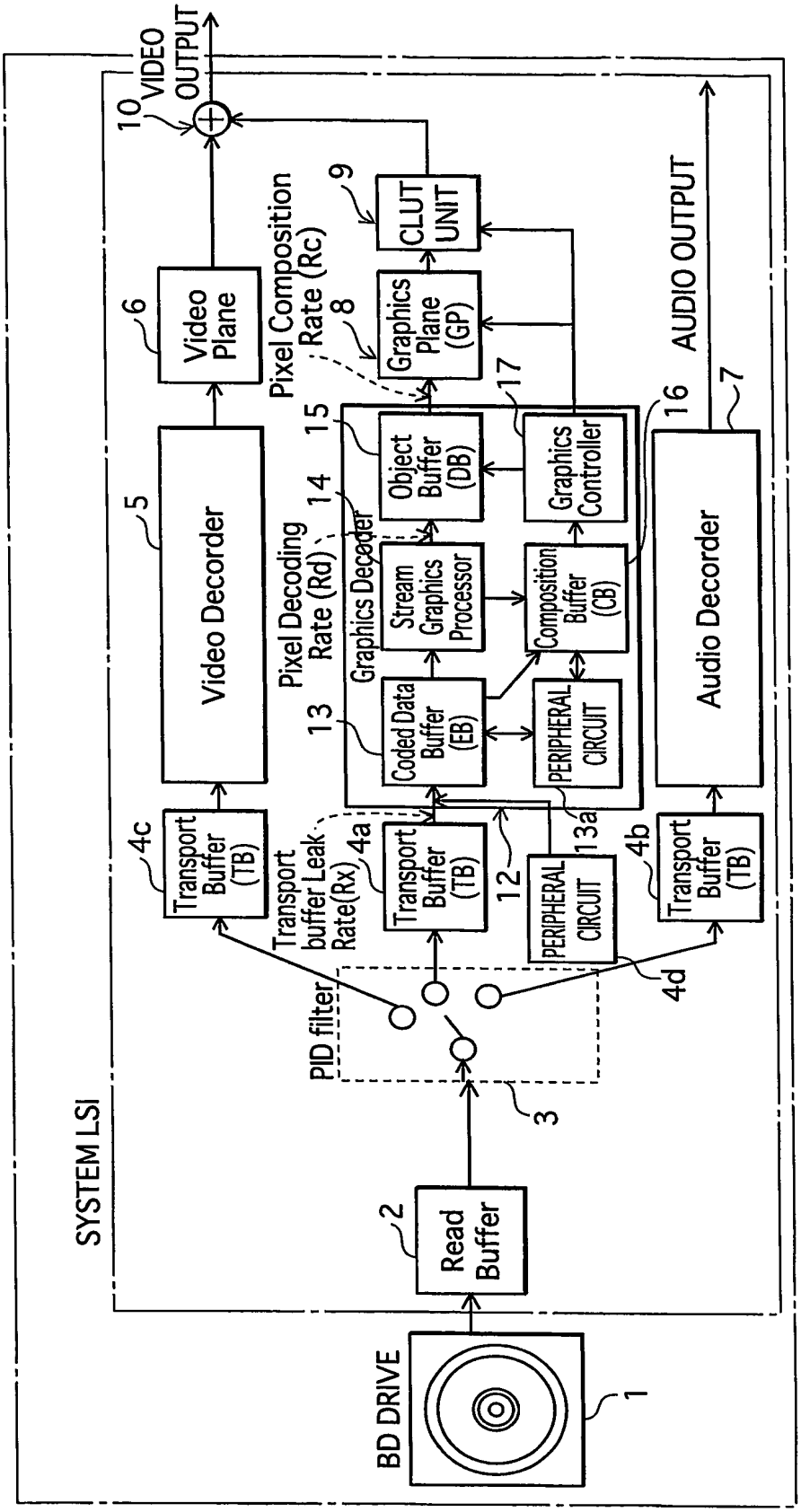

BD DRIVE
1
SYSTEM LSI
Read Buffer
2
PID filter
3
Transport Buffer (TB)
4a
Transport Buffer (TB)
4b
Transport Buffer (TB)
4c
4d
Transport buffer Leak Rate(Rx)
Video Decorder
5
Video Plane
6
Audio Decorder
7
Graphics Plane (GP)
8
CLUT UNIT
9
VIDEO OUTPUT
10
AUDIO OUTPUT
Pixel Composition Rate (Rc)
Pixel Decoding Rate (Rd)
Graphics Decoder
Coded Data Buffer (EB)
13
PERIPHERAL CIRCUIT
13a
PERIPHERAL CIRCUIT
12
Stream Graphics Processor
14
Object Buffer (DB)
15
Composition Buffer (CB)
16
Graphics Controller
17

FIG.29

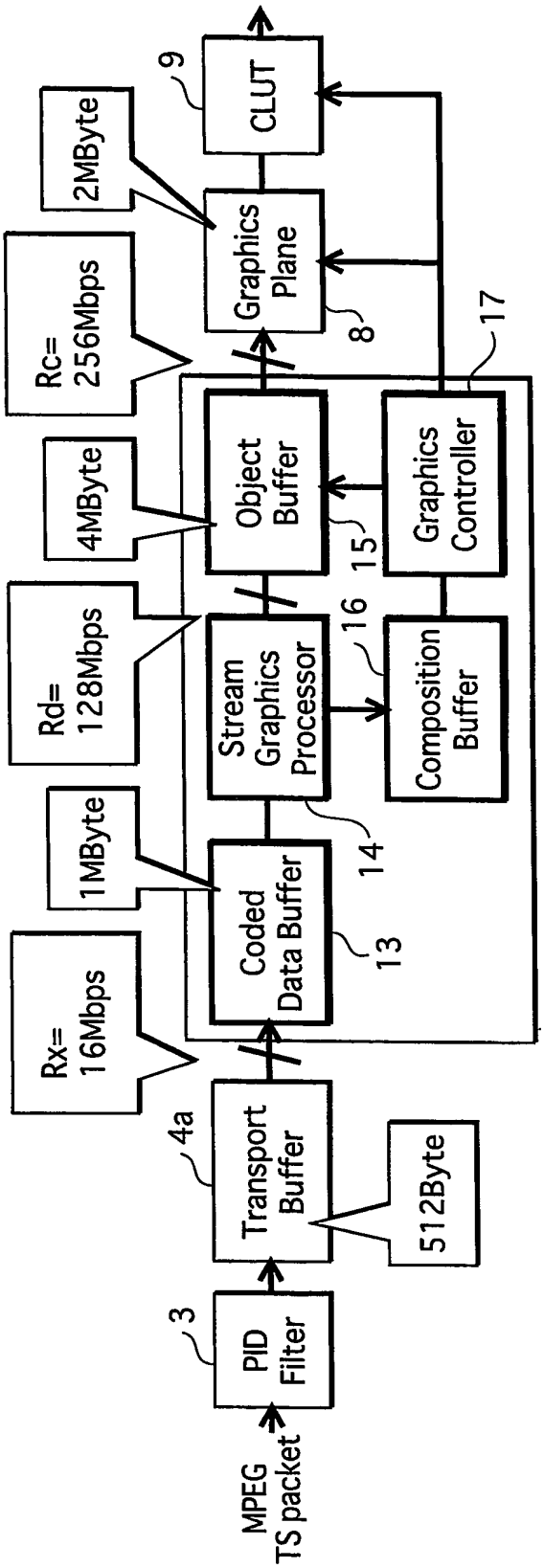

MPEG TS packet
PID Filter
3
Transport Buffer
4a
512Byte
Rx= 16Mbps
Coded Data Buffer
13
1MByte
14
Rd= 128Mbps
Stream Graphics Processor
16
Composition Buffer
4MByte
Object Buffer
15
Graphics Controller
17
Rc= 256Mbps
2MByte
Graphics Plane
8
CLUT
9

FIG.30

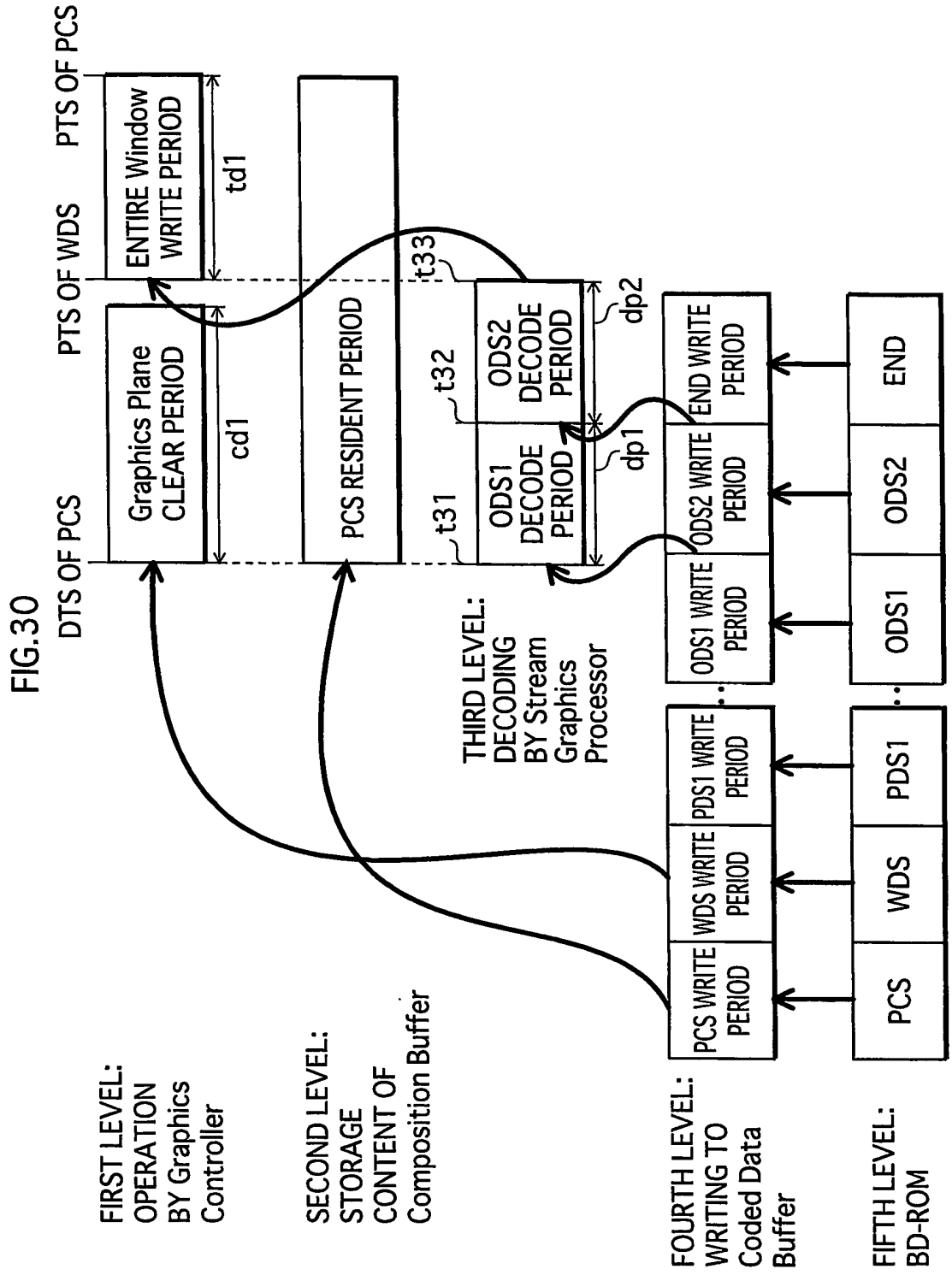
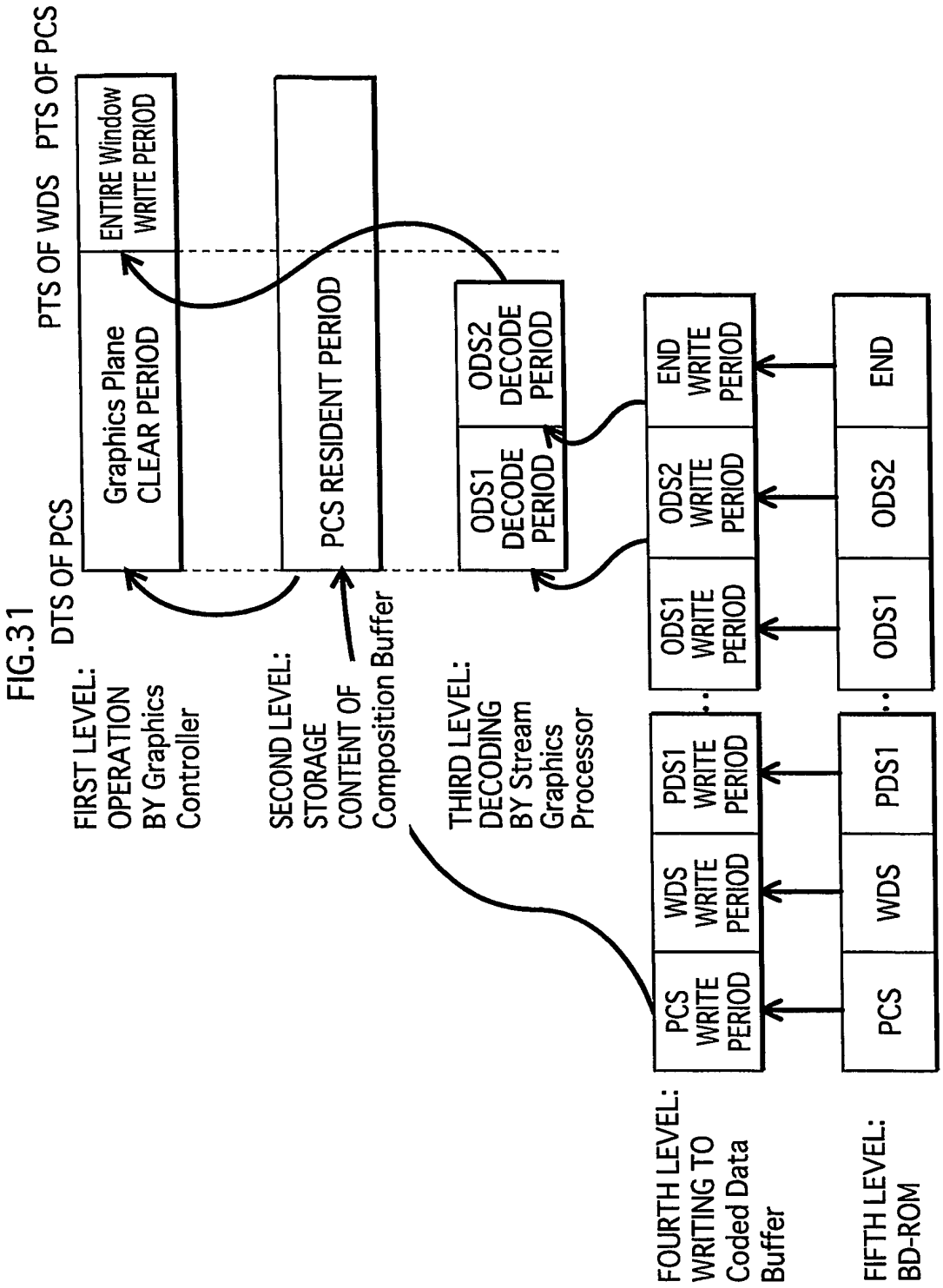

DTS OF PCS
PTS OF WDS
PTS OF PCS
Graphics Plane CLEAR PERIOD
cd1
ENTIRE Window WRITE PERIOD
td1
PCS RESIDENT PERIOD
t31
t32
t33
ODS1 DECODE PERIOD
ODS2 DECODE PERIOD
dp1
dp2
FIRST LEVEL: OPERATION BY Graphics Controller
SECOND LEVEL: STORAGE CONTENT OF Composition Buffer
THIRD LEVEL: DECODING BY Stream Graphics Processor
FOURTH LEVEL: WRITING TO Coded Data Buffer
FIFTH LEVEL: BD-ROM
PCS WRITE PERIOD
WDS WRITE PERIOD
PDS1 WRITE PERIOD
ODS1 WRITE PERIOD
ODS2 WRITE PERIOD
END WRITE PERIOD
PCS
WDS
PDS1
ODS1
ODS2
END

FIG.31


PTS OF WDS
PTS OF PCS
DTS OF PCS
ENTIRE Window WRITE PERIOD
Graphics Plane CLEAR PERIOD
PCS RESIDENT PERIOD
ODS2 DECODE PERIOD
ODS1 DECODE PERIOD
END WRITE PERIOD
ODS2 WRITE PERIOD
ODS1 WRITE PERIOD
END
ODS2
ODS1
PDS1 WRITE PERIOD
WDS WRITE PERIOD
PCS WRITE PERIOD
PDS1
WDS
PCS
FIRST LEVEL: OPERATION BY Graphics Controller
SECOND LEVEL: STORAGE CONTENT OF Composition Buffer
THIRD LEVEL: DECODING BY Stream Graphics Processor
FOURTH LEVEL: WRITING TO Coded Data Buffer
FIFTH LEVEL: BD-ROM

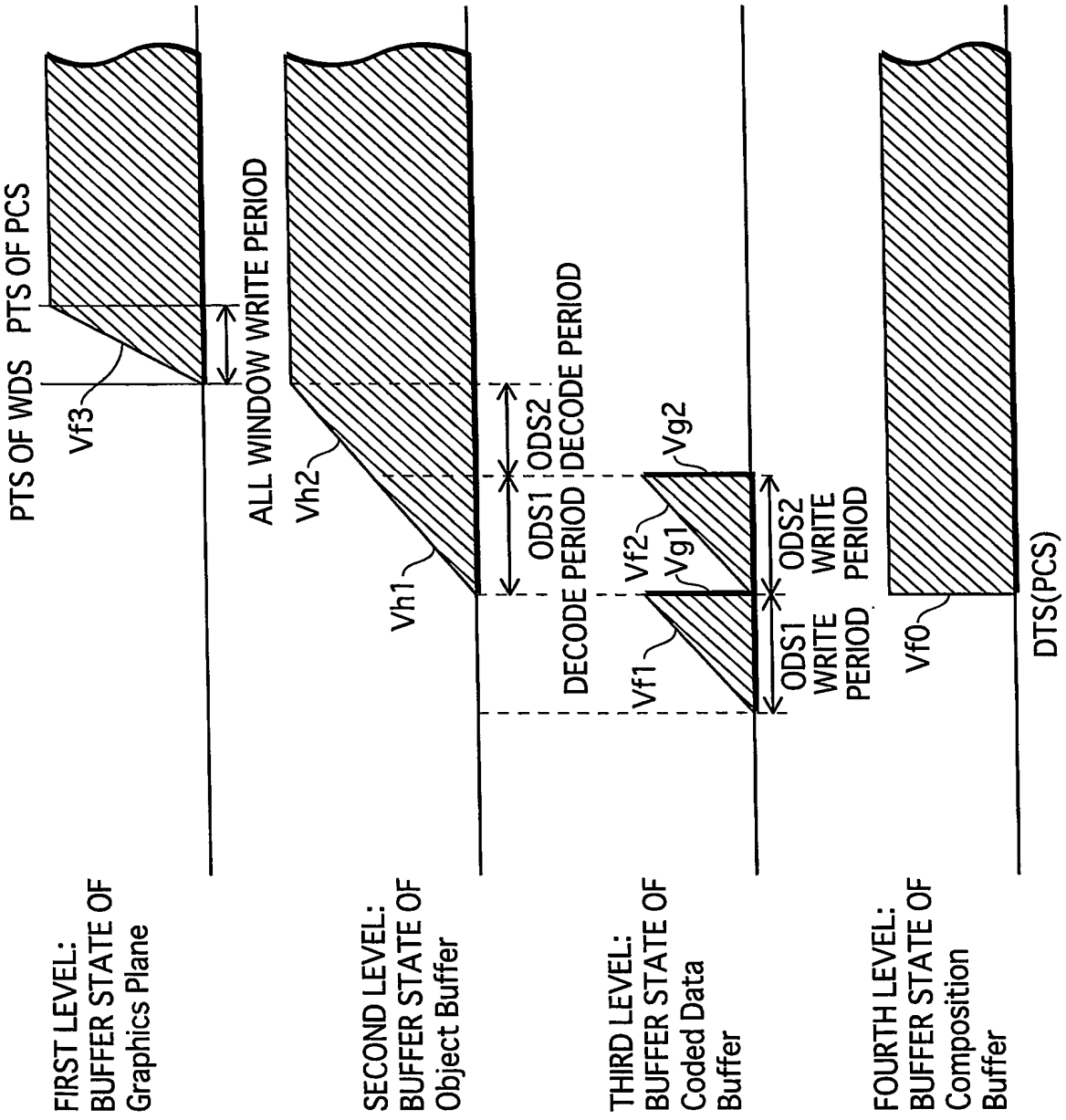

PTS OF WDS
PTS OF PCS
Vf3
ALL WINDOW WRITE PERIOD
FIRST LEVEL:
BUFFER STATE OF
Graphics Plane
Vh2
Vh1
ODS1
DECODE PERIOD
ODS2
DECODE PERIOD
SECOND LEVEL:
BUFFER STATE OF
Object Buffer
Vf2
Vg1
Vg2
Vf1
ODS1
WRITE
PERIOD
ODS2
WRITE
PERIOD
THIRD LEVEL:
BUFFER STATE OF
Coded Data
Buffer
Vf0
DTS(PCS)
FOURTH LEVEL:
BUFFER STATE OF
Composition
Buffer

FIG.32

FIG.33

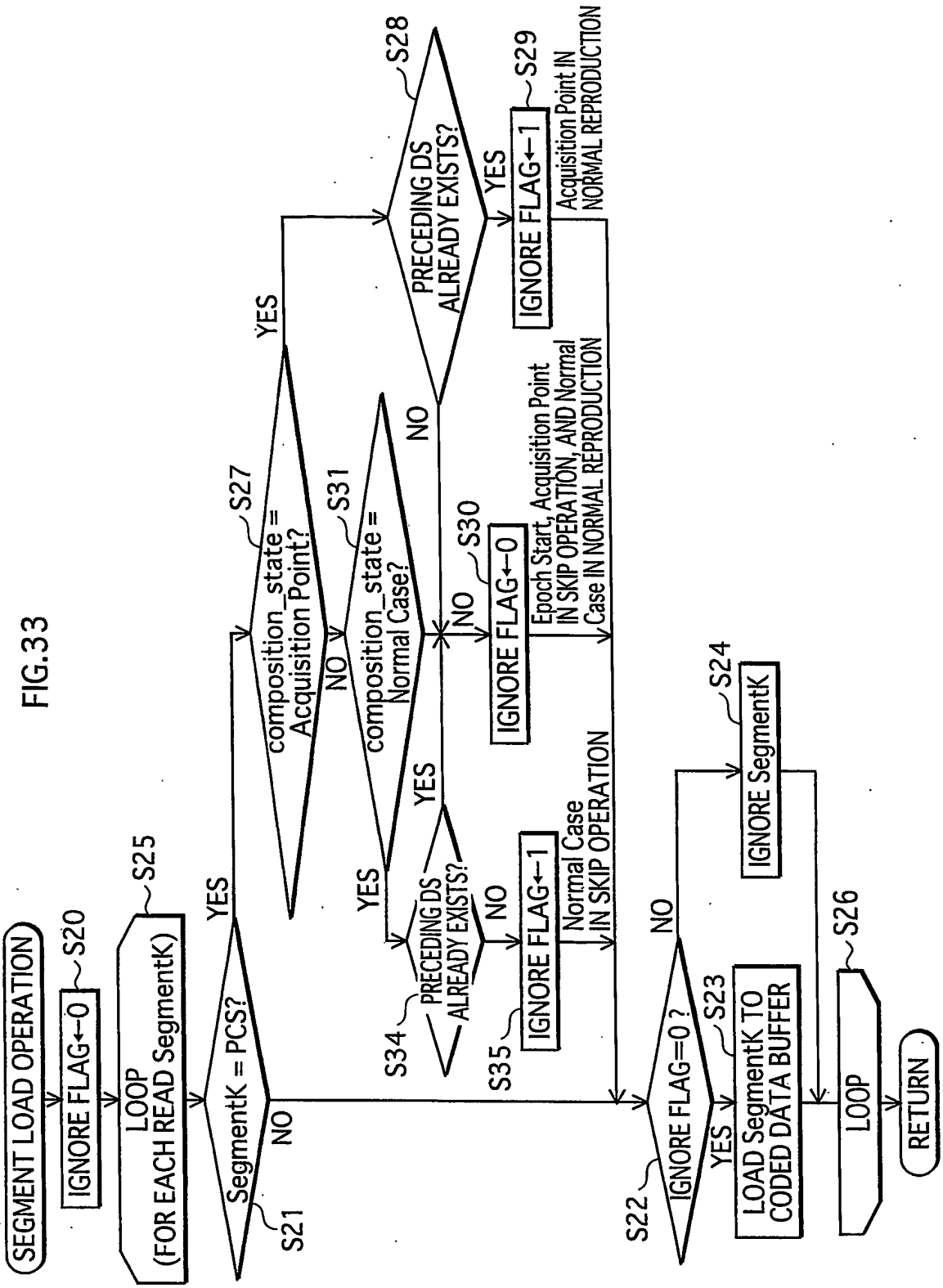

SEGMENT LOAD OPERATION
IGNORE FLAG←0
S20
LOOP
(FOR EACH READ SegmentK)
S25
SegmentK = PCS?
YES
NO
S21
composition_state = Acquisition Point?
YES
NO
S27
composition_state = Normal Case?
YES
NO
S31
PRECEDING DS ALREADY EXISTS?
YES
NO
S34
IGNORE FLAG←1
Normal Case IN SKIP OPERATION
S35
PRECEDING DS ALREADY EXISTS?
YES
NO
S28
IGNORE FLAG←0
Epoch Start, Acquisition Point IN SKIP OPERATION, AND Normal Case IN NORMAL REPRODUCTION
S30
IGNORE FLAG←1
Acquisition Point IN NORMAL REPRODUCTION
S29
IGNORE FLAG=0 ?
YES
NO
S22
LOAD SegmentK TO CODED DATA BUFFER
S23
IGNORE SegmentK
S24
LOOP
S26
RETURN

FIG.34

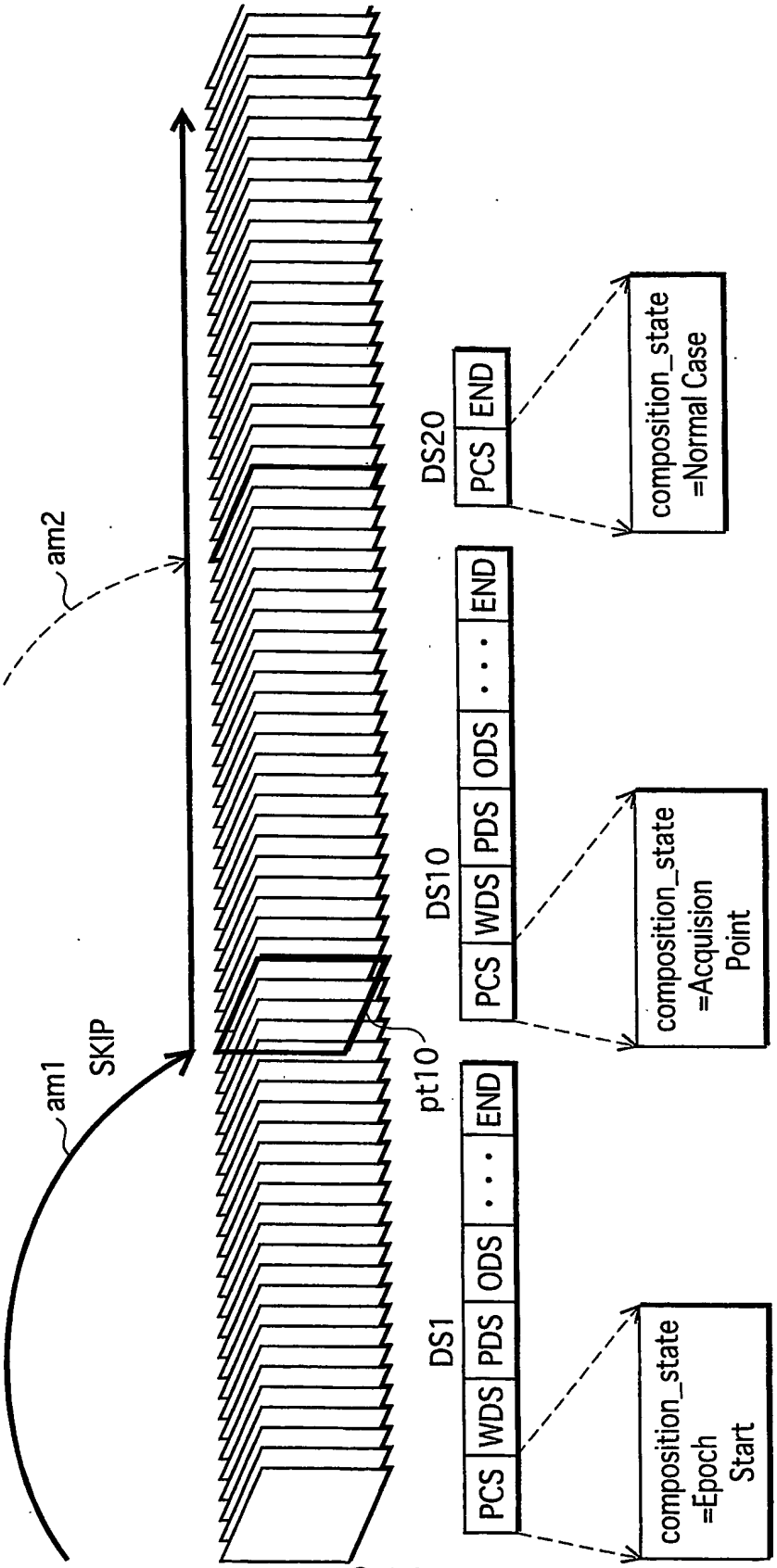

am2
SKIP
am1
pt10
DS1
PCS
WDS
PDS
ODS
• • •
END
composition_state
=Epoch
Start
DS10
PCS
WDS
PDS
ODS
• • •
END
composition_state
=Acquision
Point
DS20
PCS
END
composition_state
=Normal Case

FIG.35

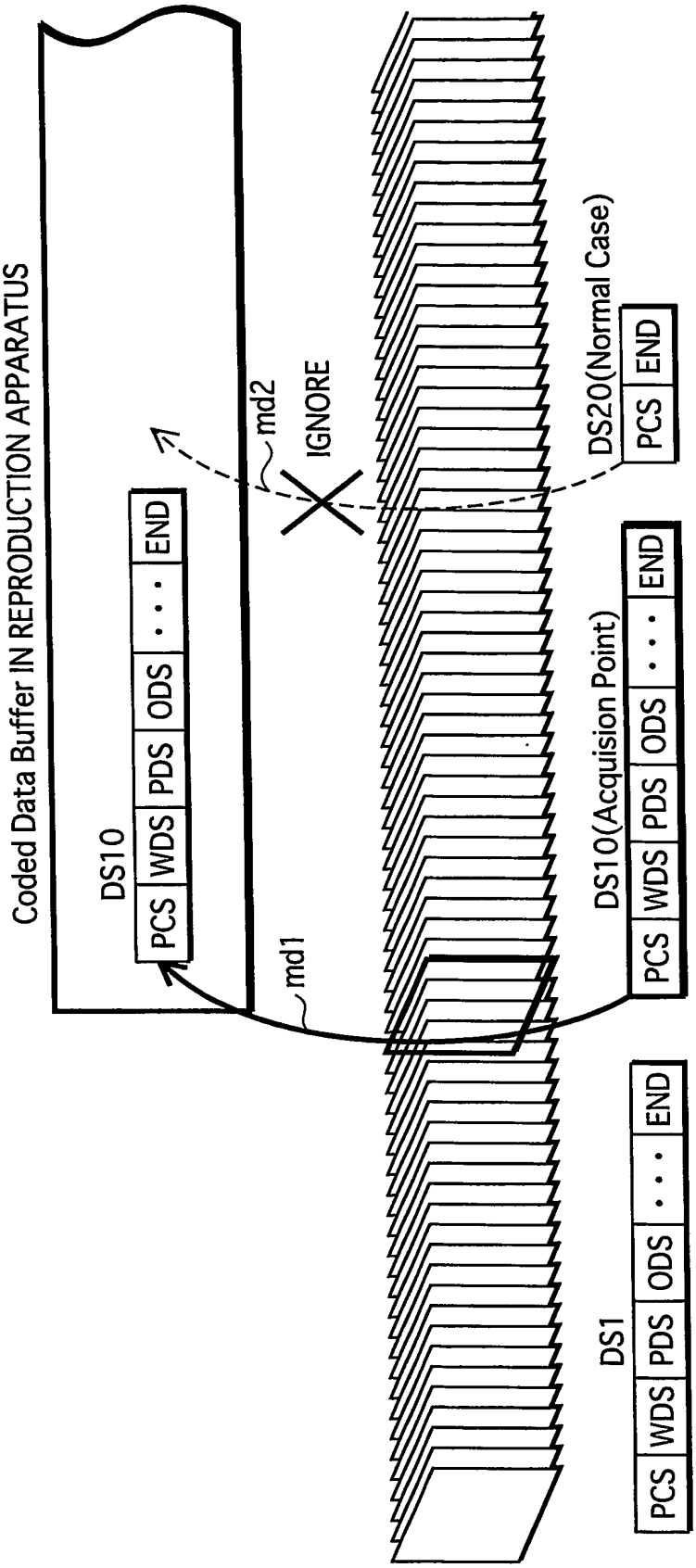

Coded Data Buffer IN REPRODUCTION APPARATUS
DS10
PCS
WDS
PDS
ODS
• • •
END
md1
md2
IGNORE
DS20(Normal Case)
PCS
END
DS10(Acquision Point)
PCS
WDS
PDS
ODS
• • •
END
DS1
PCS
WDS
PDS
ODS
• • •
END

FIG.36

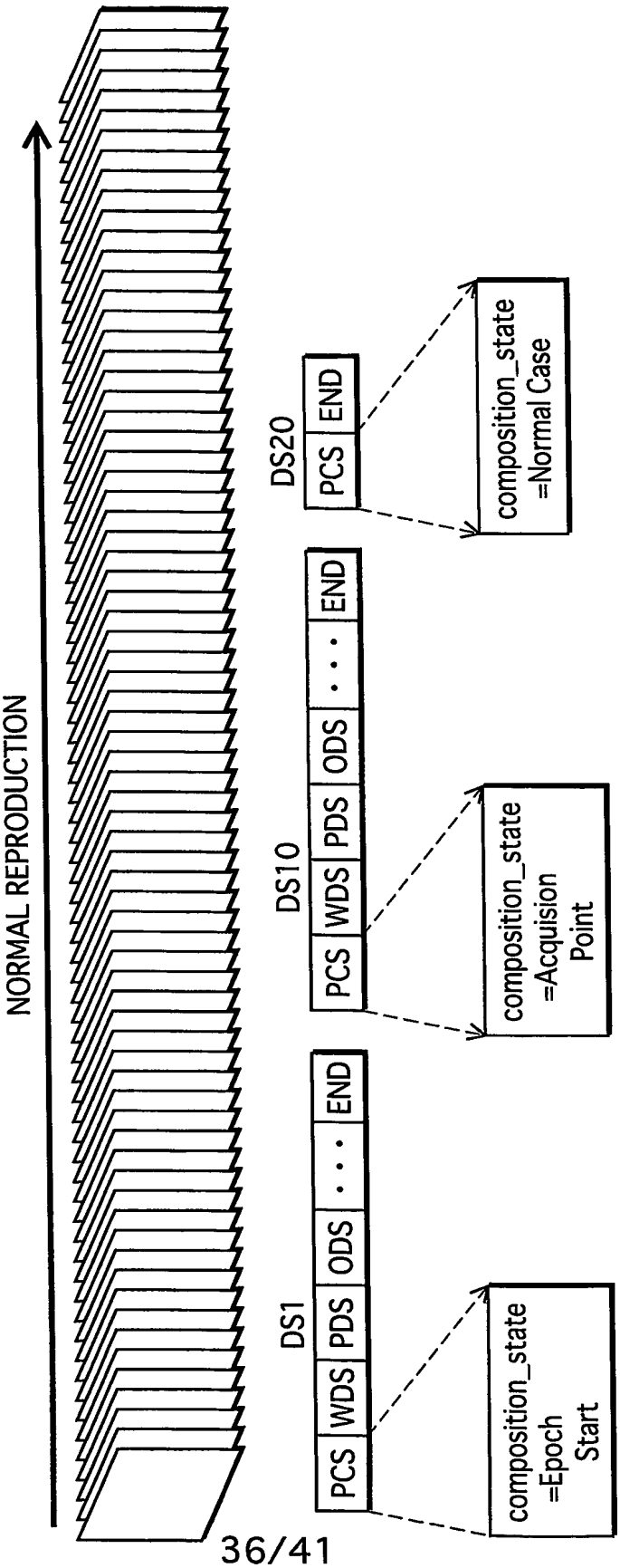

NORMAL REPRODUCTION
DS1
PCS
WDS
PDS
ODS
• • •
END
composition_state
=Epoch
Start
DS10
PCS
WDS
PDS
ODS
• • •
END
composition_state
=Acquision
Point
DS20
PCS
END
composition_state
=Normal Case

FIG.37

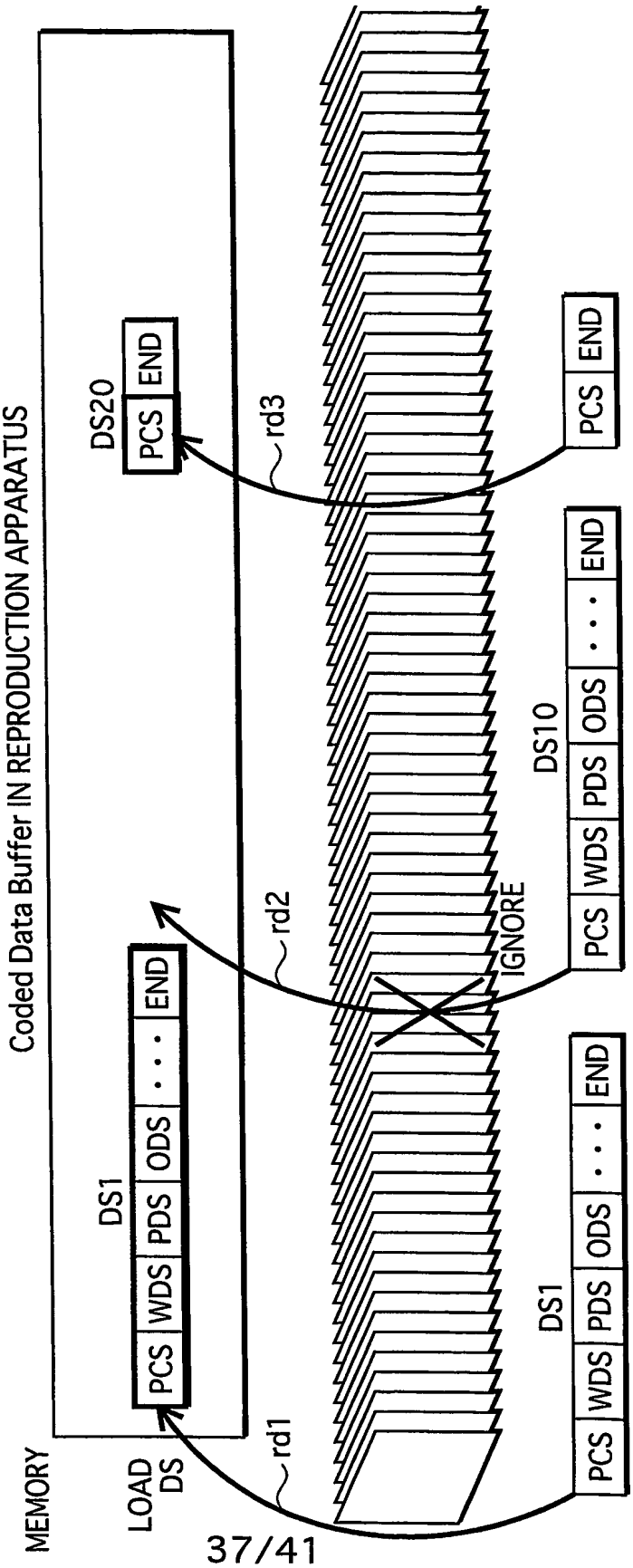

Coded Data Buffer IN REPRODUCTION APPARATUS
MEMORY
LOAD DS
DS1
PCS
WDS
PDS
ODS
• • •
END
DS20
PCS
END
rd1
rd2
rd3
IGNORE
DS1
PCS
WDS
PDS
ODS
• • •
END
DS10
PCS
WDS
PDS
ODS
• • •
END
PCS
END

FIG.38

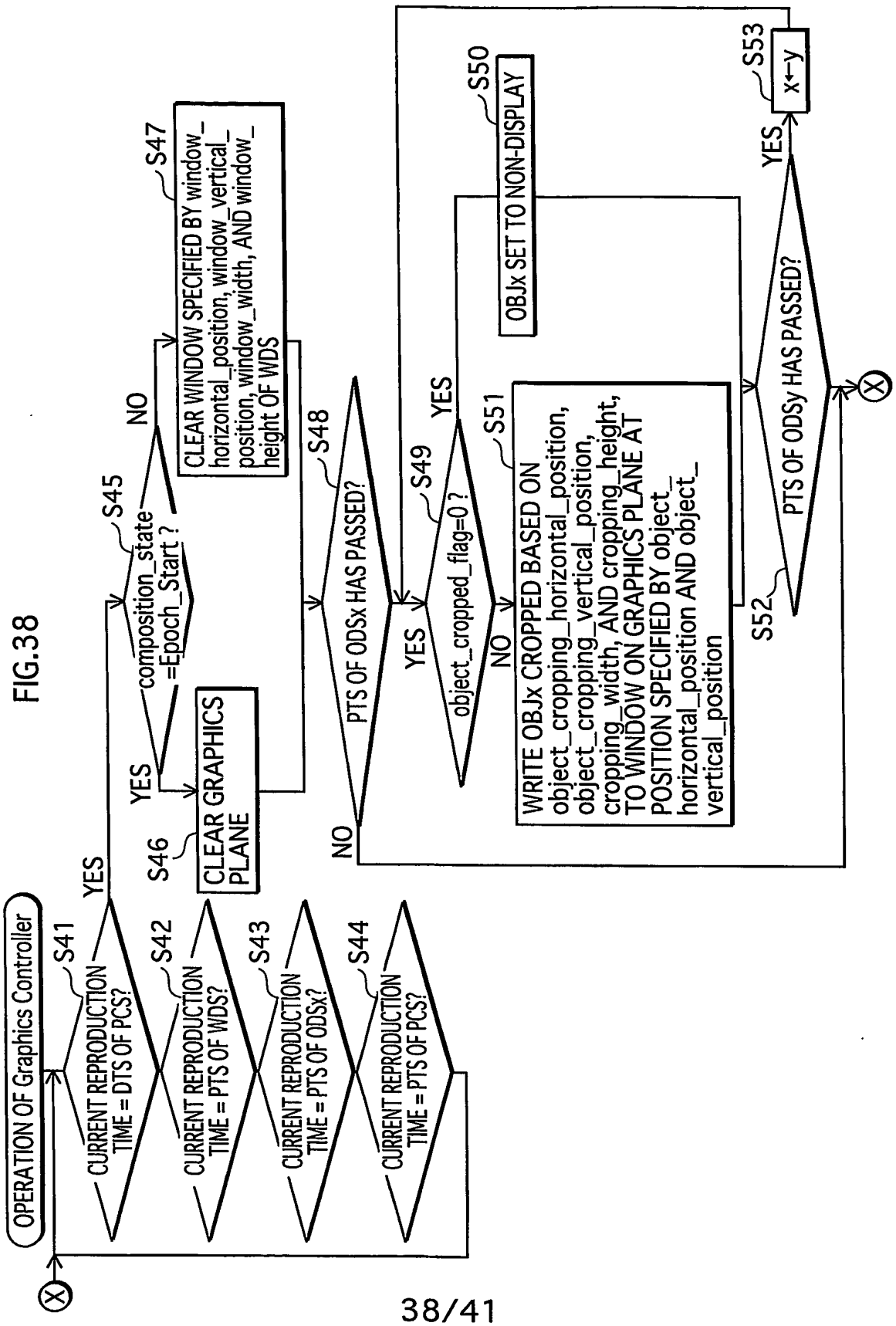

OPERATION OF Graphics Controller
S41
CURRENT REPRODUCTION TIME = DTS OF PCS?
YES
S42
CURRENT REPRODUCTION TIME = PTS OF WDS?
S43
CURRENT REPRODUCTION TIME = PTS OF ODSx?
S44
CURRENT REPRODUCTION TIME = PTS OF PCS?
S45
composition_state =Epoch_Start ?
YES
S46
CLEAR GRAPHICS PLANE
NO
S47
CLEAR WINDOW SPECIFIED BY window_horizontal_position, window_vertical_position, window_width, AND window_height OF WDS
S48
PTS OF ODSx HAS PASSED?
NO
YES
S49
object_cropped_flag=0 ?
YES
S50
OBJx SET TO NON-DISPLAY
NO
S51
WRITE OBJx CROPPED BASED ON object_cropping_horizontal_position, object_cropping_vertical_position, cropping_width, AND cropping_height, TO WINDOW ON GRAPHICS PLANE AT POSITION SPECIFIED BY object_horizontal_position AND object_vertical_position
S52
PTS OF ODSy HAS PASSED?
YES
S53
x←y

FIG.39

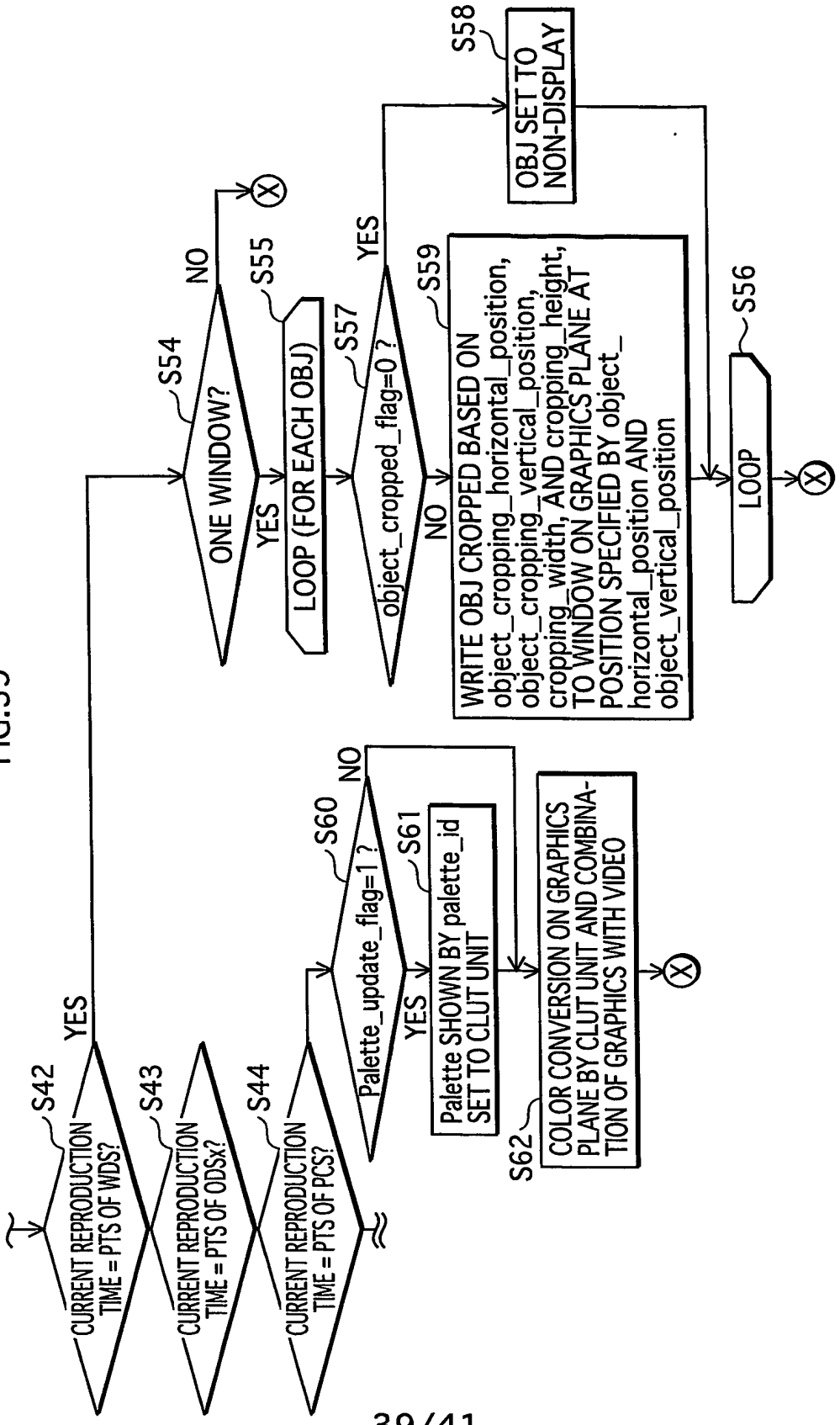

S42
CURRENT REPRODUCTION TIME = PTS OF WDS?
YES
S43
CURRENT REPRODUCTION TIME = PTS OF ODSx?
S44
CURRENT REPRODUCTION TIME = PTS OF PCS?
S60
Palette_update_flag=1 ?
NO
YES
S61
Palette SHOWN BY palette_id SET TO CLUT UNIT
S62
COLOR CONVERSION ON GRAPHICS PLANE BY CLUT UNIT AND COMBINATION OF GRAPHICS WITH VIDEO
S54
ONE WINDOW?
NO
YES
S55
LOOP (FOR EACH OBJ)
S57
object_cropped_flag=0 ?
YES
NO
S58
OBJ SET TO NON-DISPLAY
S59
WRITE OBJ CROPPED BASED ON object_cropping_horizontal_position, object_cropping_vertical_position, cropping_width, AND cropping_height, TO WINDOW ON GRAPHICS PLANE AT POSITION SPECIFIED BY object_horizontal_position AND object_vertical_position
S56
LOOP

FIG.40

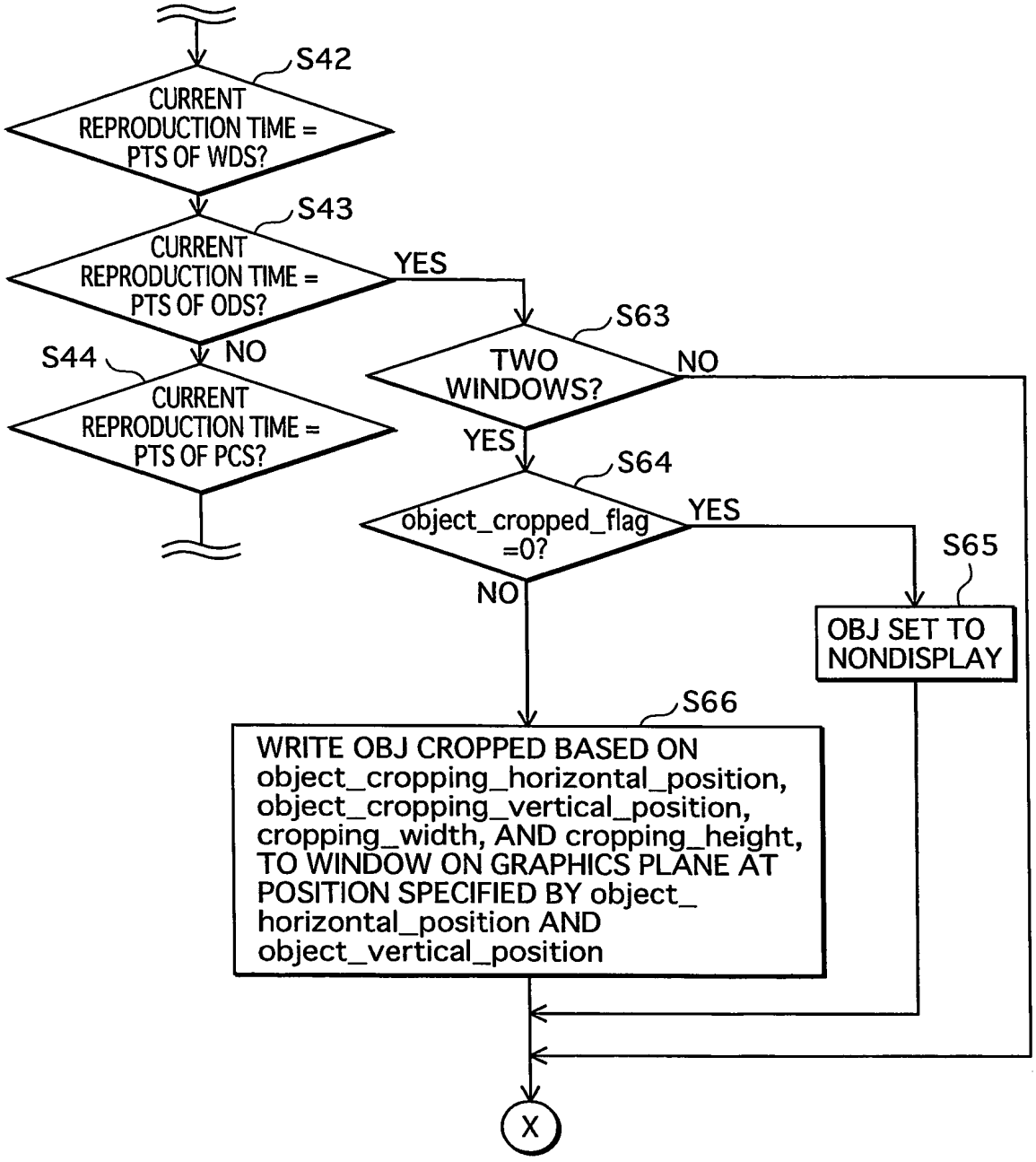
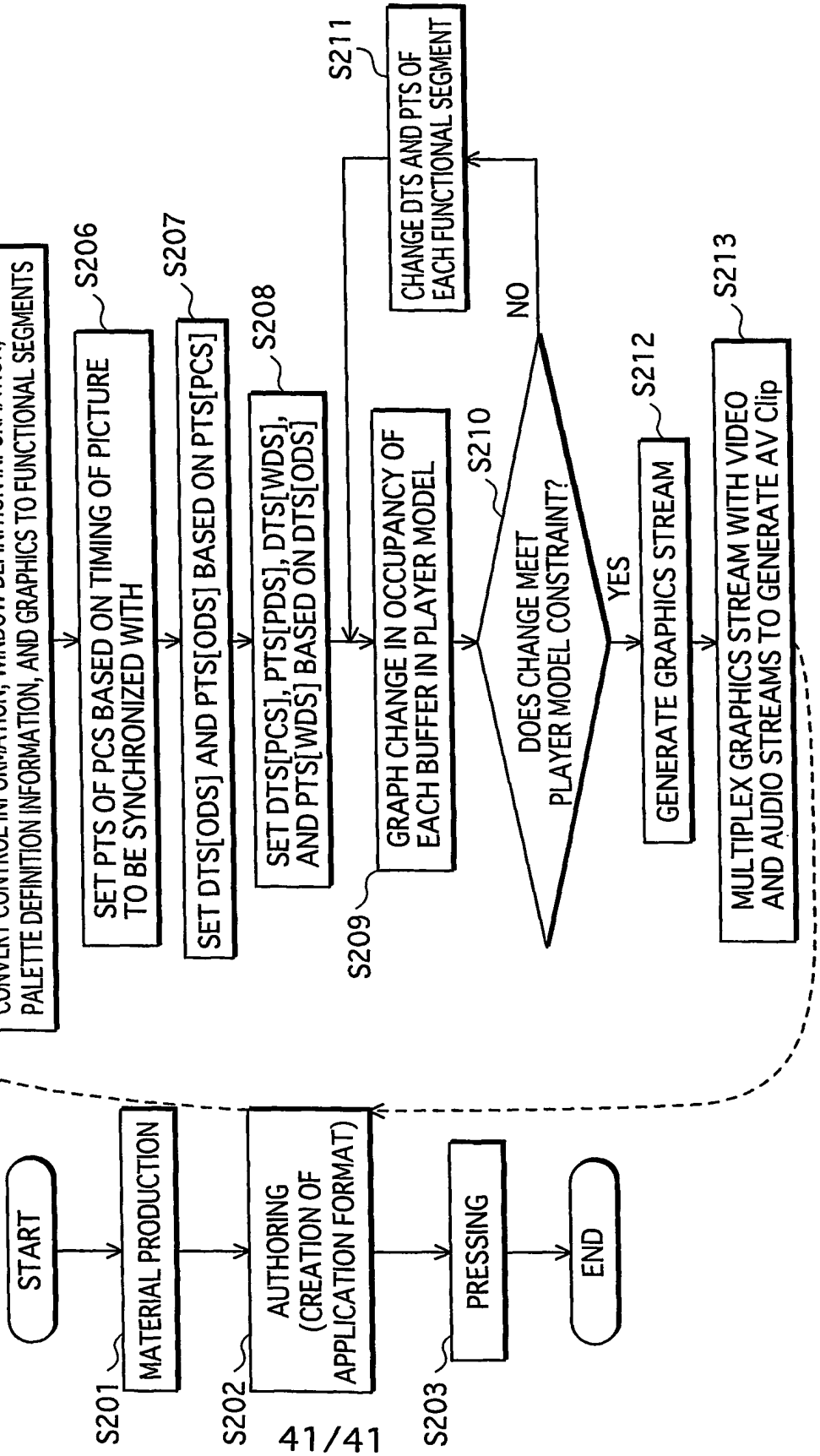

S42
CURRENT REPRODUCTION TIME = PTS OF WDS?
S43
CURRENT REPRODUCTION TIME = PTS OF ODS?
YES
NO
S44
CURRENT REPRODUCTION TIME = PTS OF PCS?
S63
TWO WINDOWS?
NO
YES
S64
object_cropped_flag =0?
YES
NO
S65
OBJ SET TO NONDISPLAY
S66
WRITE OBJ CROPPED BASED ON object_cropping_horizontal_position, object_cropping_vertical_position, cropping_width, AND cropping_height, TO WINDOW ON GRAPHICS PLANE AT POSITION SPECIFIED BY object_ horizontal_position AND object_vertical_position
X

FIG.41


START
S201
MATERIAL PRODUCTION
S202
AUTHORING (CREATION OF APPLICATION FORMAT)
S203
PRESSING
END
S204
WRITE CONTROL INFORMATION, WINDOW DEFINITION INFORMATION, PALETTE DEFINITION INFORMATION, AND GRAPHICS
S205
CONVERT CONTROL INFORMATION, WINDOW DEFINITION INFORMATION, PALETTE DEFINITION INFORMATION, AND GRAPHICS TO FUNCTIONAL SEGMENTS
S206
SET PTS OF PCS BASED ON TIMING OF PICTURE TO BE SYNCHRONIZED WITH
S207
SET DTS[ODS] AND PTS[ODS] BASED ON PTS[PCS]
S208
SET DTS[PCS], PTS[PDS], DTS[WDS], AND PTS[WDS] BASED ON DTS[ODS]
S209
GRAPH CHANGE IN OCCUPANCY OF EACH BUFFER IN PLAYER MODEL
S210
DOES CHANGE MEET PLAYER MODEL CONSTRAINT?
NO
S211
CHANGE DTS AND PTS OF EACH FUNCTIONAL SEGMENT
YES
S212
GENERATE GRAPHICS STREAM
S213
MULTIPLEX GRAPHICS STREAM WITH VIDEO AND AUDIO STREAMS TO GENERATE AV Clip